THE BRITISH SOCIETY FOR THE PROMOTION OF VEGETABLE RESEARCH

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Seventh Annual Report

1956

(OCT. 1955 - SEPT. 1956)

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NATIONAL VEGETABLE RESEARCH STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1957

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THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research', with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Ministry of Agriculture, Fisheries and Food. Until 31st March 1956, the Society depended for its funds on grants from this Ministry who were advised by the Agricultural Research Council (A.R.C.) regarding research work and staff. On 1st April 1956, the grant-aiding functions of the Ministry were transferred to the A.R.C. If the Society establishes stations or conducts work in Scotland, grants will be receivable from the Scottish Agricultural Advisory Council who will be advised by the A.R.C.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Minister of Agriculture, Fisheries and Food :

Professor K. MATHER, C.B.E., D.Sc., F.R.S., Department of Genetics, The University, Edgbaston, Birmingham, 15.

H. V. TAYLOR, Esq., C.B.E., D.Sc., A.R.C.S., V.M.H. (Chairman), Preston Grange, Barnet Road, Potters Bar, Middlesex.

Professor P. T. THOMAS, B.Sc., Ph.D., Department of Agricultural Botany, The Institute of Rural Science, University College of Wales, Penglais, Aberystwyth.

Professor C. W. WARDLAW, Ph.D., D.Sc., F.R.S.E., Department of Cryptogamic Botany, The University, Manchester, 13.

Appointed by the Secretary of State for Scotland :

R. L. SCARLETT, Esq., C.B.E., C.D.A., Sweethope, Musselburgh, Midlothian.

Appointed by the Department of Scientific and Industrial Research :

R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.

Appointed by the University of London :

Professor J. W. MUNRO, C.B.E., M.A., D.Sc., Frognall Cottage, Sunninghill, Berks.

Appointed by the University of Reading :

Professor R. H. STOUGHTON, D.Sc., A.R.C.S., V.M.H., Department of Horticulture, The University, Reading.

Appointed by the University of Cambridge :

J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Downing Street, Cambridge.

Appointed by the University of Bristol :

Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S., University of Bristol Research Station, Long Ashton, Bristol.

Appointed by the University of Edinburgh :

ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E., University Department of Botany, at Royal Botanic Garden, Edinburgh, 4.

Appointed by the Royal Society :

Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

Appointed by the John Innes Horticultural Institution :

K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

Appointed by the National Farmers' Union :

A. H. BOARDMAN, Esq., A.M.I.B.A.E., Lunts Farm, Paglesham, Rochford, Essex.

A. A. CLUCAS, Esq., Red Trees, Lathom, Ormskirk, Lancs.

G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.

J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.

W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

Appointed by the National Farmers' Union of Scotland :

DAVID LOWE, Esq., C.B.E., Elvingston, Gladsmuir, East Lothian.

Appointed by the Horticultural Trades' Association :

J. S. W. CRACKNELL, Esq., V.M.H., c/o Watkins and Simpson Ltd., 26-29 Drury Lane, London, W.C.2.

Appointed by the Royal Horticultural Society :

R. E. THODAY, Esq., A.H., R.H.S., St. John's College Gardens, 18 Madingley Road, Cambridge.

Appointed by the National Allotments and Gardens Society :

Professor J. CALDWELL, Ph.D., D.Sc., Hatherly Biological Laboratories, Prince of Wales Road, Exeter.

Appointed by the Seed Trade Association of the United Kingdom :

ARTHUR L. DEAL, Esq., c/o W. W. Johnson and Son Ltd., Boston, Lincs. (Died 15/6/56).

F. HOLL, Esq., Harrison and Sons (Leicester) Ltd., St. James' Street, Leicester. (From 16/8/56).

The Executive Committee

Professor W. BROWN
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq.
DAVID LOWE, Esq. (Chairman)
Professor K. MATHER
Professor J. W. MUNRO
Professor R. H. STOUGHTON
W. F. SWIFT, Esq.
Professor T. WALLACE

Staff and Research Sub-Committee

Professor W. BROWN (Chairman)
A. A. CLUCAS, Esq.
A. L. DEAL, Esq. (Until 17/1/56)
DAVID LOWE, Esq.
Professor K. MATHER
Professor J. W. MUNRO
R. L. SCARLETT, Esq. (From 18/1/56)
Professor R. H. STOUGHTON
Dr. H. V. TAYLOR
Dr. R. G. TOMKINS
Professor T. WALLACE

Co-opted :

C. E. HUDSON, Esq., C.B.E., N.D.H., V.M.H., Ministry of Agriculture, Great Westminster House, Horseferry Road, London, S.W.1.

Farm Management Sub-Committee

A. H. BOARDMAN, Esq.
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq.
J. LAITY, Esq.
R. L. SCARLETT, Esq.
W. F. SWIFT, Esq. (Chairman)

Co-opted :

E. R. HOARE, Esq., B.Sc. (Eng.), M.I.E.E., National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds.

Varieties Inspection Sub-Committee

A. A. CLUCAS, Esq.
J. S. W. CRACKNELL, Esq.
G. G. HOLE, Esq. (From 18/1/56)
F. HOLL, Esq. (From 17/10/56)
DAVID LOWE, Esq. (Chairman)
W. F. SWIFT, Esq.

Co-opted :

C. D. R. DAWSON, Esq., Ph.D., Pyports, Cobham, Surrey.

F. G. POTTER, Esq., Sutton and Sons Ltd., The Royal Seed Establishment, Reading, Berks.

STAFF

Director :
JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.).

Plant Breeding : J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.
H. HOLLAND, B.Sc. (Wales).
A. G. JOHNSON, B.Sc. (Lond.), Ph.D. (Wales).
L. E. WATTS, B.Sc. (Wales).
G. J. FAULKNER.
G. J. FROST, B.Sc. (Dunelm).
R. A. T. GEORGE. (Appointed 24/10/55)

Assistants : Miss C. H. BEARDALL, Dip. Hort. (Nott.).
D. D. CLARKE.
Miss P. A. DYMOND.
Miss W. HORN.
Miss J. M. H. INSLEY.
I. MITCHELL.
Miss P. M. RUSSELL.

Chemistry : F. HAWORTH, B.Sc., Ph.D. (Liverpool), Dip. Ag. Sci. (Cantab.). A.R.I.C.
S. P. SPRAGG, B.Sc., Ph.D. (Bristol).
E. E. H. PITT. (Resigned 30/9/56)

Assistants : P. B. BANHAM.
Miss M. BENNETT.
Mrs. A. DAVIES (née Burgess).
Miss J. WAGHORN. (Resigned 30/9/56)

Irrigation : E. J. WINTER, M.C., M.Sc. (Bristol).
P. J. SALTER, M.Sc., Hort., Ph.D. (Nott.).
G. STANHILL, B.Sc., Ph.D. (Reading).

Assistants : B. G. HUNT. (Returned from National Service 1/12/55)
A. MORGANS. (Returned from National Service 1/1/56)
J. PARKER. (Resigned 30/9/56)
Miss J. I. E. RUBIO.
Miss J. SMITH.

Entomology : D. W. WRIGHT, M.A. (Cantab.).
J. A. DUNN, M.Sc. (Dunelm).
W. R. HOWELLS, B.Sc., Ph.D. (Wales). (Resigned 23/8/56)
R. D. HUGHES, B.Sc., Ph.D. (Lond.). (Appointed 12/9/56)
G. A. WHEATLEY, B.Sc. (Dunelm).
Miss D. D. BOWE, B.Sc. (Dunelm).
J. S. BUXTON, B.Sc. Hort. (Nott.).
J. A. HARDMAN, B.Sc. Hort. (Nott.).

Assistants : H. I. SMITH.
Miss J. MARCH.
Miss C. R. MARTIN.
Miss S. PHILLIPS. (Appointed 30/4/56)
Miss A. SARGENT.

Pathology : W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.
A. G. CHANNON, B.Sc. (Aberdeen).
Mrs. D. E. KNIGHT (née Fisher), B.Sc. (Lond.), M.Sc. Hort. (Nott.), A.R.C.S. (Working under A.R.C. grant).
J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
Miss J. S. HOWELL, B.Sc. (Birm.).
Miss B. R. SMITH, B.Sc. Hort. (Lond.). (Appointed 1/1/56)
J. M. WAY, B.Sc. (Lond.).
M. J. W. WEBB, B.Sc. Hort. (Nott.).

Assistants : Miss J. CARPENTER.
Miss P. A. DADLEY.
Miss M. P. INSALL. (Working under A.R.C. grant).
Miss A. P. WARD, N.D.D.H. (Studley).

Weed Ecology : H. A. ROBERTS, B.Sc. (Manc.).
J. K. A. BLEASDALE, B.Sc., Ph.D. (Manc.).
Miss M. E. SMART, B.Sc. (Lond.).

Assistants : Mrs. I. H. FROST. (Appointed 1/1/56)
Mrs. A. H. T. GEORGE. (Appointed 21/5/56)
Miss U. W. LAURENCE.
Miss C. M. ROWE. (Resigned 15/10/55)

Statistics : J. A. NELDER, M.A. (Cantab.).
D. COOKE, B.A. (Oxon.).

Assistants : Miss A. MEADUS.
Miss H. E. RUSSELL.

R. B. AUSTIN, B.Sc. (Birm.). (Appointed 1/10/56) Physiology.

Librarian : Miss B. M. BAGGS, M.Sc. (Liverpool).
Photographer : Miss J. KULLMAN. (Appointed 27/2/56)

Farm : *Manager :* T. J. NORWOOD.
Foremen—Wellesbourne : I. F. REYNOLDS.
Paglesham : D. T. McVITTIE.

Administration : *Secretary :* J. C. WILKINS, LL.B. (Lond.), F.C.I.S.
Accounts Assistant : D. A. BARTLETT.
Administrative Assistant : L. C. FITZGERALD.
Director's Secretary : Miss E. B. FORRESTER.
Office Assistants : Mrs. J. BLOUNT. (Appointed 28/5/56)
Miss J. M. B. EDGERTON. (Resigned 31/12/55)
Mrs. J. M. FAULKNER (née Lamb).
Miss S. B. TOOKEY.
Miss M. A. WARR.

REPORT OF THE DIRECTOR

DEVELOPMENT

No building development on the research side took place during the year. Unfortunately, the architect and the quantity surveyor were short of staff and this caused delay in the preparation of detailed plans and bills of quantities for the main block of laboratories and offices, including library and lecture room. Tenders were invited, however, in November 1956 ; one was accepted in January 1957 and work was due to begin soon afterwards.

The Station has been dependent since its inception on funds provided by the Ministry of Agriculture, Fisheries and Food who were advised by the Agricultural Research Council regarding research work and staff. In accordance with a Government decision, all the responsibilities of the Ministry as the grant-aiding authority were transferred to the A.R.C. on 1st April 1956.

The relationship between the Station and the Ministry had grown into one of friendly and helpful co-operation and it is pleasing to know that the Ministry is anxious to continue this relationship. We are grateful to the Ministry for all the help given, especially in the development of the Station, and while we regret the break in our close association, we shall continue to collaborate with the Ministry in order to strengthen the connection between research and practice. Our relations with the A.R.C. also have been pleasant and we look forward to developing co-operation which will be in the best interests of the Station and its research on the problems of vegetable production.

STAFF

Appointments

Dr. R. D. Hughes joined the staff as a Scientific Officer in the Entomology Section on 12th September 1956. He had previous experience of research work in the Far East on insect-borne diseases and their control.

Mr. R. B. Austin was appointed on 1st October 1956 as a Scientific Officer to work on physiological problems. Previously he worked in British Guiana on the growth and nutrition of sugar cane.

Mr. R. A. T. George, who came from the Botanic Garden of the University of Cambridge, was appointed on 24th October 1955 as an Assistant Experimental Officer in the Plant Breeding Section.

Miss B. R. Smith, previously employed at the University of Nottingham, A.R.C. Unit of Potato Storage Investigations, was appointed as an Assistant Experimental Officer in the Plant Pathology Section on 1st January 1956.

Five Scientific Assistants were appointed during the year :—

Mrs. I. H. Frost, Weed Ecology
Mrs. A. H. T. George, Weed Ecology
Miss S. Phillips, Entomology
Miss C. Horswill, Irrigation
Miss J. Kullman, Photographer
(temporary appointment for three months)

During the summer, five University students were employed to assist in the research sections.

Mrs. J. Blount was appointed as a Clerical Officer on 28th May 1956.

National Service

Mr. B. Hunt and Mr. A. Morgans rejoined the staff as Scientific Assistants in the Irrigation Section on completion of their National Service training.

Resignations

Dr. W. R. Howells, on obtaining a post with the South-West Wales River Board, resigned on 23rd August 1956.

Mr. E. E. H. Pitt and Mr. J. Parker resigned on 30th September 1956 on gaining entrance to Bristol University and Leeds University, respectively.

Miss C. M. Rowe resigned on 15th October 1955 to take up training in radiography. Miss J. M. B. Edgerton resigned her post on 31st December 1955 to return to work of a horticultural nature, and Miss J. Waghorn resigned on 30th September 1956 to train as a speech therapist.

We are pleased to congratulate Dr. P. J. Salter and Dr. G. Stanhill on having been awarded Ph.D. degrees by the University of Nottingham and the University of Reading, respectively. Dr. Salter did the work for his thesis at Nottingham before coming to Wellesbourne, and Dr. Stanhill did his work at Wellesbourne while holding a Ministry of Agriculture, Fisheries and Food scholarship.

Several conferences were attended during the year by members of the research staff. Mr. Wright attended the three-day National Crop Protection Conference at Eastbourne and read a paper entitled 'A survey of soil pests affecting vegetable crops'. Dr. Keyworth read a paper on 'Silvering disease of red beet' at a meeting of the Association of Applied Biology held in London during December. Mr. Roberts addressed the British Weed Control Council Symposium on Phenoxybutyric Herbicides, held in London in February, on the subject of 'The response of vegetable crops to applications of some phenoxybutyric acids under field conditions'. Dr. Keyworth, Miss Smith and Dr. Tomlinson attended the N.F.U. Watercress Conference at Market Deeping in March when Dr. Tomlinson read a paper on 'Recent research on watercress diseases'. During April, Dr. Salter, Dr. Stanhill and Mr. Winter were present at the Soil Science Conference held in London, and together with Dr. Bleasdale gave a demonstration of 'Methods of measuring leaf area' at a symposium on leaf growth at Sutton Bonington, which was also attended by Mr. Cooke and Mr. Roberts. Dr. Keyworth and Mr. Wright were present at the three-day Plant Protection Conference held in June at Fernhurst. The A.R.C. Plant Breeders' Conference held in Cambridge on 4th and 5th July was attended by the Director, Dr. Haigh, Mr. Holland, Dr. Johnson, Mr. Nelder and Mr. Watts.

Mr. Wright visited Canada in August to attend the 10th International Congress on Entomology in Montreal, and afterwards was able to visit research laboratories in Canada and the United States by means of a grant kindly made by the A.R.C. Dr. Haworth was present at the 6th International Congress of Soil Science, held in Paris, during the latter part of August and beginning of September.

In September, Dr. Salter and Dr. Stanhill attended the British Association meeting at Sheffield. Mr. Winter read a paper on 'Irrigation of vegetables' at the Horticultural Education Association Autumn Conference at Worcester, when Station exhibits on irrigation and on cabbage root fly were staged and, during the same month, Miss Howell and Dr. Keyworth were present at the Association of Applied Biology Symposium in London, where Dr. Keyworth spoke on 'The use of streptomycin for the control of silvering disease of beet.'

An exhibit was staged at the Chelsea Show, in the Scientific Section, by the Entomology Section, showing the life history of the cabbage root fly and methods of controlling the pest.

On 12th September 1956 a recording was made by the B.B.C. of an unrehearsed discussion of the objects and results of some of the work of the Station. Those who took part were Mr. Percy Thrower, on behalf of the B.B.C., Dr. Philp, Dr. Haigh, Dr. Keyworth and Mr. Roberts and the recording was broadcast in the Home Service

on 16th September 1956. It was suggested by the B.B.C. that another discussion in which other members of the staff would take part might be recorded and broadcast in the spring of 1957.

The Christmas lunch on 15th December 1955 was enjoyed by 85 members of staff, together with two guests from Norway and four from the Ministry of Agriculture, Fisheries and Food. The Station choir, conducted by Mr. Wilkins and accompanied by Mr. Faulkner at the organ, gave a programme of carol singing in St. Peter's Church, Wellesbourne, on the evening of 19th December 1955 which was well attended and enjoyed by the Station staff and local residents. On 6th January 1956 the fifth Christmas-New Year party was held in the canteen when the staff and their friends, numbering 96, had a most entertaining time. The Sports and Social Committee organised the party and thanks are due to them, and to many other members of staff, for the very successful evening. On 13th April, the same Committee organised a dinner dance for the staff and their guests at the Ettington Park Hotel when 72 people were present. In all, three social evenings were held during the year.

The Sports and Social Committee consisted of Miss Bennett, Miss Bowe, Miss Horn, Dr. Tomlinson (Chairman), Mr. Cooke (Treasurer) and Mr. Watts (Secretary). The cricket club played 18 matches of which they won eight, lost six and drew four, and also organised a dinner for members of the Station team and their friends. The hockey club won two, lost four and drew one of their matches during the season. Owing to bad weather only two lawn tennis fixtures were arranged with local clubs, and one of these matches was won by the Station team. A table tennis club was formed in March 1956 and of the six matches played against other clubs, five were won by the N.V.R.S. A stamp club was also formed during the year.

The return visit on 9th June of the Long Ashton Research Station cricket and tennis teams was the most important sporting occasion at the Station and, although the weather was not favourable, Long Ashton avenged their tennis defeat of the previous year while the N.V.R.S. did likewise on the cricket field so that honours were even over the two years.

Special thanks are due to the Trustees of the Clucas Trust Fund for a donation which was made to purchase a piano for the station. The piano has been bought and is giving great pleasure to members of staff.

RESEARCH

An important development occurred during the summer of 1956 in that an arrangement was made between the University of Birmingham and the N.V.R.S. whereby the special experience and knowledge of the Station's staff could be made available for the benefit of the University's students, while at the same time research work carried out by post-graduates at the Station could be recognised for the purposes of obtaining internal higher degrees of the University. The Director, Dr. Keyworth and Mr. Wright were appointed by the University as Recognised Lecturers, and accepted candidates for higher degrees will have their research work supervised by a member of the staff of the University and by a Recognised Lecturer. During the first year, candidates will be required to make a certain number of attendances at the University, and thereafter the attendances will be arranged at the discretion of the supervisors. Approved candidates may be members of the staff of the Station, or visiting workers on scholarships, etc., or may be seconded to the Station by the University. In addition to the advantages of having the Station recognised for the purpose of obtaining higher degrees, we look forward to developing close and friendly co-operation with the University which will be encouraged by the scheme and will be of mutual benefit. We are grateful to the University of Birmingham for extending this privilege to the Station and we thank Professor K. Mather, Professor E. J. Maskell and Professor O. Lowenstein for the part they played in fostering the scheme. It is a pleasure to record that, in October 1956, the University seconded a student to work at the Station for a higher degree and that two members of the staff were accepted as candidates for higher degrees.

Plant Breeding

F_3 generations of summer lettuce plants, from 58 F_2 plants which showed no symptoms of mosaic virus disease, were grown beside diseased plants. Only three F_3 families developed no symptoms and this material was used for further breeding and selection. An experiment demonstrated that the extent of natural crossing in lettuce was such that isolation was necessary for the production of hybrid-free seed.

Progress has been made in breeding and selection work aimed at producing a non-bolting Detroit type of red beet having single-seeded fruit.

F_1 hybrids between onion varieties (male sterile plants having been used as female parents) were found to have greater vigour, earlier maturity and fewer bull-necked bulbs than the parent varieties. Similar results were obtained with pair crosses within a variety as compared with selfs.

The programme of making hybrid varieties of Brussels sprouts has reached the stage where third generations of inbred lines of Cambridge varieties have been produced. This has led to an average loss of vigour of 40 per cent, and to the recognition of inherently good lines and of those having genetic defects. Tests have shown that some crosses between second generation inbred lines gave considerably higher yields than the variety from which the lines were derived. Another test has shown that the progeny from 16 mass pollinated plants, selected on the basis of the performance of their first generation progeny, gave a significantly higher yield than the parent variety.

Inbreeding work was begun with early summer cauliflower Cambridge No. 5. First generation inbred lines showed little inbreeding depression in vigour, as expected, and two lines were about a week earlier in reaching maturity.

Further data were obtained on the amount of natural crossing which occurred between brassicas at different isolation distances on the Station. It appeared that an isolation distance of seven furlongs led to a percentage of natural crossing which, although low, could not be disregarded in the production of pure seed.

Nucleus stock seed of those Cambridge varieties which are on the market was supplied to the N.I.A.B. for the production of stock seed which, in turn, will be supplied to recognised seed growers for the production of commercial seed under the scheme described in the Annual Report for 1952.

Chemistry

The three long-term field experiments which were laid down in 1953 on soil of relatively low fertility have now completed the first cycle of the three-year crop rotation of vegetables. So far, the FYM has had much the best effect on the yield of all the crops—spring cabbage, summer cabbage, leeks, carrots, red beet and early potatoes. In general, nitrogen and potash have had small effects on yields, while phosphate benefited only early potatoes, even although the phosphate status of the soil was low. Inorganic nitrogen was superior to organic nitrogen (hoof and horn meal) in its effect on quick growing crops. With cabbage, one early dose of inorganic nitrogen had an equal or better effect than the same total amount applied in four separate doses. Brussels sprouts and leeks responded better on the average to deep ploughing than to shallow ploughing or rotavating although the opposite applied to leeks in the first cropping year.

Analytical work has been carried out on plant material from some of the above field experiments. With red beet from the NPK-FYM experiment, the different manurial treatments in 1955 and 1956 produced no differences in the percentage dry weight of roots and of leaves, and produced smaller differences in chemical composition than those brought about by weather differences. The sucrose content of roots was increased by the high level of potash in 1955 but not in 1956, and was unaffected by the high level of nitrogen. In 1955 the high level of nitrogen decreased the protein content (as percentage of the dry matter) in both leaves and roots, whereas in 1956 this treatment increased the protein content.

Irrigation

Early summer cauliflowers were grown under three soil moisture regimes, and were protected from rain. The plants which were given a wet treatment produced bigger curds and were four days later in maturing than those given medium or dry treatments. In 1955, early summer cauliflower grown on a deeper soil showed no difference in response to irrigation treatments.

Carrots, protected from rain, gave a higher yield but had more split and fanged roots with a continuously wet treatment than with a dry one.

In another experiment, a wet treatment and a dry treatment were applied to carrots during their first two weeks of growth. They were protected from rain during this two-week period but otherwise were exposed to rain. During these same two weeks the treatments were applied to another lot of carrots during their second two weeks of growth, to another lot during their third two weeks of growth, and so on till maturity. The results showed that neither the wet nor the dry treatment applied at different stages in development of the crop produced significant differences in the yield of roots. The dry treatments applied any time up to the eighth week, or between the thirteenth week and maturity, however, produced three times the number of split and fanged roots as compared with the corresponding wet treatments. This suggests that there are distinct periods when an upset in the moisture supply has an adverse effect on the root development of carrots.

An experiment with lettuce indicated that the longer the soil was kept at field capacity, from the seedling stage onwards, the greater was the percentage of marketable plants produced. Plants grown from the seedling stage through to maturity in soil kept at field capacity gave the largest heads and the greatest percentage of marketable heads.

Irrigation experiments, using oscillated spraylines on a rotation of vegetable crops, were begun in collaboration with the E.H.S. at Luddington and Stockbridge House. No protection from rain was given. At Stockbridge House, the effects on the crops produced by a wet treatment did not differ significantly from those produced with no irrigation. At Luddington, on the other hand, a wet treatment, as compared with no irrigation, produced significant differences in the following respects: reduced the average size of marketable heads of early lettuce; increased the yield and size of marketable curds of early summer cauliflower; increased the weight of leaves produced by early carrots; and increased the number and the weight of marketable plants of self-blanching celery.

Several new instruments were installed in the crop weather station and in consequence further progress was made in the studies on water loss from plants and soil.

Entomology

Experiments were carried out again to measure the extent of damage on the yield and quality of brassica crops caused by cabbage root fly, and to assess the degree of control achieved by treatment with soil insecticides. The cool, wet summer of 1956 apparently delayed egg laying by the fly, and reduced the number of predators.

Comparison of different insecticidal treatments showed that lindane applied as a seed dressing gave good control of stem weevil and of cabbage root fly with brassicas in the seed-bed. This treatment is used also for the control of flea beetle in the seed-bed. It is not recommended for use on turnips or radishes, however, because it may spoil the flavour of the roots.

Previous investigations showed that good control of the first generation of carrot fly was obtained with seed dressings of lindane on fen soils, and with lindane or dieldrin on mineral soils. Subsequent sprays with dieldrin were necessary, however, to reduce the attacks of the second generation of carrot fly on maincrop and late carrots. Field experiments in 1956 have shown that low rates of aldrin, dieldrin, or lindane when broadcast and rotavated into the soil, gave almost complete control of both first and second generations of the fly, and gave protection from attack on carrots grown in the second year after treatment. Both the aldrin and dieldrin broadcast

treatments had little effect on the flavour of the carrots but lindane produced off-flavour or taint. Further investigation of the effects of the insecticides on carrot flavour and on succeeding crops in the rotation, and on the crop uptake of insecticide must be carried out, however, before these broadcast treatments can be recommended.

The attack of root aphid on summer lettuce was so slight at Wellesbourne in 1956 that it was not possible to assess the effects of insecticidal treatments, or the relative degrees of resistance of varieties already known to possess some resistance to attack. The low infestation resulted from cool, wet weather and from a severe attack by predators. Evidence was obtained that wingless root aphids can overwinter in the soil and infest another crop of summer lettuce on the same site in the succeeding year.

Studies were continued on the biology of the carrot fly and its larvae which attack parsnips. Field experiments indicated that dieldrin sprayed on the soil before mid-August and followed immediately by earthing up the rows of parsnips gave a moderately good control of the pest. Disposing of the crop or clamping it before mid-November should obviate much damage since serious mining was observed to begin then and to become progressively worse during December and January.

Further laboratory and field studies were made on temperature effects on the rate of development of pea moth larvae.

Pathology

Following the discovery that traces of zinc in water suppressed crook root disease of watercress, investigations have been in progress towards developing the use of zinc in a practical method of control. Laboratory work was followed by trials in experimental and commercial beds during the winter of 1955-56. Zinc frit, consisting of finely powdered glass containing zinc oxide, was applied to the floor of the beds. Zinc was liberated very slowly and in minute quantities from the zinc frit and this gave a striking reduction in the disease and improvement in the crop. The low zinc content of the effluent from the beds was not toxic to fish and the amount in the watercress was harmless for human consumption. In view of these promising results extensive trials have been laid down during 1956-57.

In an experimental bed, chlorine gave complete control of the disease but had a toxic effect on the watercress. In another bed an increase in the calcium bicarbonate content of the water completely controlled the disease and markedly enhanced the crop vigour, but the cost of the treatment was too great to be of value to commercial growers.

Studies have been continued on the effect of virus infection on the yield of watercress, on the host range of the virus and on the vectors. An experiment showed that the virus was not transmitted through watercress seed and hence virus-free stocks of green cress can be raised from seed.

The seed-borne bacterium causing silvering disease of red beet was shown to be a new species and has been named *Corynebacterium betae*. Seed treatment with the antibiotic streptomycin gave a satisfactory control of the disease. Promising results have also been obtained by dusting the seed with a mercurial compound 'Harvesan'. This substance is easier to obtain and to apply than streptomycin. Silvering disease was found in a seed crop of mangolds in 1956.

Various compounds were tested for their effectiveness, when sprayed on stems of outdoor tomato plants, as eradicants of, and/or protectants against *Didymella* stem rot disease. Various derivatives of dithane were the most effective, both as eradicants and protectants, while captan and thiram were good as protectants but not as eradicants. Heavily infected seed failed to give diseased mature plants but it does not necessarily follow that this will always happen. Overhead irrigation of tomato plants increased the spread of disease among the plants. The pathogen was found to persist in contaminated soil for one year, but probably not for two years and this suggests that at least a two-year interval should elapse between tomato crops on the same site.

The work on parsnip canker has resulted in the isolation of a species of the fungus *Itersonilia* from infected roots. The fungus has been found to enter the roots readily through wounds but it can also penetrate apparently undamaged tissue, producing

lesions identical in appearance with those on naturally cankered roots. In tests made in three successive years, insecticidal treatments which almost completely eliminated carrot fly attack, have failed to influence the final amount of canker.

Tests of various fungicides for the control of *Botrytis* disease of winter lettuce, confirmed the previous findings that thiram gave a good control with both frame lettuce and lettuce transplanted from frames in spring.

Weed Investigations

Previous results showed that weedy corn land, upon which long-term experiments were laid down, had the very high population of viable weed seeds in the soil of not less than 180 millions per acre. Recent results showed that the population of weed seeds was reduced by about half as a result of the first year of vegetable cropping, and that the reduction differed for different weed species. Investigations were continued on the behaviour and life cycle of important annual weeds of vegetable crops, and on the emergence of annual weed seedlings as affected by different methods of preparation of seed-beds. Further studies were made on the competition between weeds and vegetable crops and information was obtained on the economics of weeding in crop production.

Further work confirmed that dinoseb (amine) was an effective post-emergence herbicide for use with market garden peas. Dinoseb (amine) may be applied at an early stage in the development of the crop virtually without injuring it, and thus achieves a high degree of weed control. Early varieties of peas differed in their susceptibility to injury by dinoseb (amine) while late varieties did not differ in this respect ; none of the varieties tested, however, showed damage of any practical importance.

Trials again showed that peas were tolerant of MCPB but that it gave poor control of some of the commonest weed species. For the latter reason, MCPB is likely to be limited in its use with pea crops.

Monuron, previously known as CMU, continued to give good control of annual weeds in established asparagus beds without affecting yield or quality of the crop. The annual speedwell (*Veronica persica*), however, was not controlled by monuron and in one trial it multiplied rapidly when protected from the competition of other weeds by the action of the herbicide. Another trial again showed that monuron as a pre-emergence treatment gave an excellent result in the control of annual weeds in asparagus seed-beds.

CIPC (isopropyl N-(3-chlorophenyl) carbamate) was tested for the control of chickweed (*Stellaria media*) and annual meadow grass (*Poa annua*) in onions and in transplanted spring cabbage, and some newly available compounds were tested for their suitability for weed control in vegetable crops.

Statistics

The Statistics Section, as usual, has given advice and assistance to the research staff, and to the N.A.A.S. Experimental Horticulture Stations and other bodies. Studies were continued on methods of improving the accuracy of field experiments with cauliflowers, carrots, onions and lettuce. Data produced by the Station's tasting panel were also investigated and, in consequence, several improvements were made in the design and practice of the tasting tests. Work was continued on the genetics of continuous variation in French beans.

The Director has continued to serve on the Advisory Committees of the N.A.A.S. Experimental Horticulture Stations, and to act as Chairman of the Vegetable Working Party which co-ordinates the experimental work on vegetables at these Stations. The close collaboration between these Stations and the N.V.R.S. has been maintained and we thank all who were concerned in carrying out field experiments in extension of those done at Wellesbourne by the various research sections.

The N.I.A.B. and the N.V.R.S. continued to co-operate closely in seed maintenance and multiplication work and in the trials of varieties, and the Director again served on the Vegetable Trials Advisory Committee of the N.I.A.B.

Visitors

The Station held its first Open Day on 5th June 1956 when about 500 visitors saw exhibits illustrating the work of the research sections, and toured the experimental areas in the field. Other visitors, totalling 455, came to the Station during the year, of which the following were from overseas :—

Australia :	Dr. Frank Penman, C.S.I.R.O., Victoria.	
British Guiana :	Mr. N. Ahmed, Dundee, Mahaicony.	
Ceylon :	Mr. B. L. W. Fernando, Marketing Department.	
Cyprus :	Mr. V. D. Krentos, Department of Agriculture, Nicosia.	
East Africa :	Chief Shangali, Moshi, Tanganyika.	
Ethiopia :	Mr. Tessema Kebede Mr. Kassahun Abebe Mr. Mulugeta Gebrewold	Ministry of Agriculture, Addis Ababa.
France :	M. Jean-Baptiste de Vilmorin, Paris. M. G. Trébuchet, Paris.	
Holland :	Dr. O. Banga, I.V.T., Wageningen. Mr. J. Meijer, Philips Research Laboratory, Eindhoven.	
Hawaii :	Dr. and Mrs. C. F. Poole, University of Hawaii, Honolulu.	
India :	Dr. S. M. Singh, University of Agra. Mr. B. M. Gupta, Agriculture Department, Delhi Mr. S. K. Sengupta, Government of West Bengal, Calcutta Mr. T. S. Sundaram, Government of Orissa, Bhubaneswar	Colombo Plan Students.
Norway :	Professor Georg Hygen, Agricultural College of Norway, Vollebekk. Dr. and Mrs. Kaare Aamlid, State Experimental Station, Landvik.	
Pakistan :	Dr. M. Ishaque, Agricultural Experiment Station, Dacca. Mr. S. Khan, Department of Plant Protection, Karachi Mr. M. M. S. Malik, Department of Plant Protection, Karachi Mr. A. Sattar, Agricultural Experiment Station, Dacca	Colombo Plan Students.
Philippines :	Mr. B. Bombay, Bureau of Plant Industry, Manila Mr. M. Menguito, Bureau of Plant Industry, Manila Mr. L. Orejudos, University of Philippine, Laguna Mr. G. T. Palis, Bureau of Plant Industry, Manila Mr. V. L. Saplala, Philippine Sugar Institute, Manila	
Thailand :	Mr. C. Thwut, Department of Agriculture, Bangkok.	
U.S.A. :	Mr. Frank G. Cuthbertson, Ferry-Morse Seed Company, California. Miss Patricia Sarvella, N. Carolina State College, Raleigh.	
West Africa :	Mr. J. P. Mayhew, Department of Agriculture, Accra, Gold Coast.	

The following parties visited the Station :—

1955	
22nd November ...	Staff and senior pupils from the Leamington College.
1956	
27th April ...	Members of the Dutch Countrywomen's Association.
14th May	Staff and members of the Junior Common Room, National Institute for Research in Dairying.
5th June	N.F.U. Vegetables Committee.
9th June	Members of the F.A. Secrett Club.
14th June	Staff and senior pupils of the Kenilworth County Secondary Modern School.
15th June	Staff and students from the School of Agriculture, Sutton Bonington.
26th June	N.A.A.S. Provincial Pathologists and Assistant Pathologists.
20th July	Party of Rural Science Instructors from the Vocational School, County Kilkenny.
31st July and 1st August ...	N.A.A.S. Horticultural Advisory Officers.
15th August ...	Staff and final year honours students from the Botany Department, Birmingham University.

Acknowledgments

Special thanks are given to members of the staff who have carried out duties in addition to their normal work. A Library Committee, Miss Baggs, Dr. Haworth, Mr. Nelder and Mr. Roberts, assisted with library matters, and the Glasshouse Committee, Dr. Haigh, Dr. Keyworth, Mr. Norwood, Mr. Winter and Mr. Wright, again gave useful service. The Canteen Committee consisted of Miss March, Miss Ward, Mr. Bartlett (Treasurer), Mr. Hardman (Secretary), Mr. Salter, and Mr. Way (Chairman), who carried out their onerous duties well and largely in their own time. Mr. Nelder assisted in the editing of this Annual Report.

Grateful acknowledgment is also made to other members of the staff who assisted in many ways, and to all the staff and employees for the loyalty with which they carried out their work.

Thanks are due to the Executive Committee and the Sub-Committees, and particularly to the Chairman of the Governing Body and the Chairmen of the Committees for the assistance they have given.

Thanks are also due to all those friends of the Station, particularly growers and commercial firms, who have kindly donated seeds, plants and other material, and who have helped in many other ways. Special mention is made of the kind gift by Mr. A. A. Clucas of the first edition of 'The first, second and third bookes of the historie of plants' by John Gerard, published in 1597.

It is with regret that we record the death of Mr. A. L. Deal on 15th June 1956. Mr. Deal had served on the Governing Body and on the Staff and Research Sub-Committee of the Station since its inception, and provided a valuable link between the Station and the Seed Trade. He served also as one of the first three trustees of the Clucas Trust Fund.

J. PHILP,

15th *February* 1957.

FARM

By T. J. NORWOOD

Wellesbourne

The dry weather which started in June 1955 continued with few breaks until the end of June 1956. At Wellesbourne, the favourable weather during spring facilitated the preparation of seed and planting beds, and consequently everything was sown and planted in good time. During the early part of the summer the ground was dry and the irrigation system had to be employed to the full permitted capacity to cope with the needs of various crops. Insect pests, weevils and aphids in particular, threatened to become troublesome, but applications of insecticides saved the young vegetable plants from serious attacks. In May there was abundant grass and about 80 tons each of hay and silage were made by the end of June.

In July, the weather broke and harvesting was most difficult. Only by taking advantage of every dry period (the barley was mostly combined in two-hourly spells in the evenings) was it possible to save all the cereals. The grass which had begun to suffer because of the long dry spell was given a new lease of life, however, and there was such a heavy crop that about 120 tons of silage was made in late September, some of the lucerne being cut for the fourth time. Root crops were heavy and improvement in the late autumn weather enabled them to be harvested without undue difficulty.

The policy of feeding stock in yards for dung-making was continued and 50 attested fat bullocks were sold between December 1955 and June 1956. The remaining 32 were grazed on the leys during the summer. Our registered, attested, pig herd has been increased by retaining the best bacon type gilts for breeding. During the year, 30 litters were born from which 264 pigs were reared. Most of the pigs were sold for bacon but a few gilts were transferred to Paglesham or were sold for breeding.

A second Dutch barn was erected thus enabling all the straw to be stored under cover. The building of a Harper Adams pig house to accommodate about 120 baconers was completed during the summer. Grain storage bins, and grinding and mixing machinery were installed in the old barn to enable full use to be made of home-grown grain, the only foods bought being high protein meals and millers' offals for pig fattening, and cubes which are more economical for outside feeding to sows.

Further plantings of quickthorn hedges and of young specimen trees were made.

Paglesham

At Paglesham we were unfortunate in losing the services of Mr. K. J. Rampling who moved to a new post at the beginning of April. Mr. D. T. McVittie was appointed as farm foreman and took up his duties at the beginning of June. During the intervening period, Mr. I. F. Reynolds, foreman at Wellesbourne, acted as foreman at Paglesham.

The severe February weather spoiled the red cabbage crop from which it had been intended to select plants for seed, but the other cropping was carried out as planned. Crops of onions, Brussels sprouts and broccoli were grown for seed production. The winter wheat grew well and a heavy crop was saved despite a troublesome harvest. Oats and barley were also good. The potatoes suffered an attack of blight and the haulm had to be killed early in September. The young ley undersown in spring wheat in O.S. 126 became firmly established. Grass was abundant everywhere and a 60 tons stack of silage was made in October. An old ley, O.S. 54, was ploughed in mid-summer and fallowed to prepare it for cropping in 1957.

Thirty cattle which had overwintered in the yards were grazed on O.S. 48 and sold for beef during the summer. In late summer, 30 cattle were bought for winter yarding. Three further gilts and a young boar were supplied from the Wellesbourne pig herd and the Paglesham herd is now a self-contained unit for the production of bacon pigs.

PLANT BREEDING REPORT

By J. C. HAIGH

BREEDING PROJECTS

Lettuce (L. E. Watts and R. A. T. George)

The F_3 generation from the crosses made between varieties showing little attack by lettuce mosaic virus (3) was grown in 1956 in three blocks ; in each block rows of plants of the selfed progenies of the 58 symptomless plants of the previous generation alternated with rows of artificially-inoculated plants of Borough Wonder as a source of infection. Each plant was examined for mosaic symptoms, and Mr. Watts found continuous variation from complete lack of symptoms (in three of the progenies) to symptoms in every plant (in one progeny). There was no significant correlation between the degree of expression of mosaic symptoms in a progeny and the parentage of that progeny. In order to determine whether the lack of symptoms is due to tolerance or immunity, back inoculations from symptomless plants to a susceptible variety are being made by Dr. Tomlinson of the Plant Pathology Section. Selected plants have been seeded for further study.

A collection of wild species of *Lactuca* is being made and examined for resistance to mosaic. We are grateful to the many people in this country and abroad, who have kindly sent seed samples.

Seed of the susceptible variety Borough Wonder was irradiated, in the hope that a resistant mutation might be produced. The first treatments were exploratory, to decide the type of radiation and the dose most suitable, and less than a quarter of the treated seed produced plants which survived to maturity. These plants were put out in the field between rows of artificially-inoculated plants of the same variety (but grown from untreated seed) and all developed mosaic symptoms ; back inoculations showed that they were indeed infected with mosaic. In the hope, however, that a recessive resistant mutation may have resulted from the irradiation, progenies of the plants from treated seed will be exposed to infection in 1957. We are indebted to the Technological Irradiation Group of the Atomic Energy Research Establishment for their ready co-operation.

An experiment to determine the extent of natural crossing in lettuce was made in 1955. Plants of a green variety were surrounded by plants of a pigmented variety, and natural seed was collected from the green plants. Successional sowings were made so that any effect of seasonal variation in insect activity on crossing could be noted. The natural progeny of the green plants showed that there was a range of from 0.15 per cent to 11.52 per cent of natural crossing according to time of flowering. A more detailed account of the experiment will be published elsewhere.

Red beet (H. Holland and G. J. Frost)

The results of three years' trials with varieties of red beet will be found later in this report.

The F_2 generation was raised from the F_1 of a cross between self-fertile, monogerm, late-bolting, poor quality material derived from sugar beet, and a good strain of Detroit red beet (3). Seed was sown early in December 1955 and the first bolters appeared in mid-April ; this flush of bolting lasted for two weeks, and was followed by a second flush of bolting which lasted from the end of May to the end of June. Four plants did not bolt. Both early and late-bolting classes contained both monogerm and multigerm types, but there was linkage between the early-bolting and multigerm characters. The table overleaf gives the numbers of plants obtained in each class and, in brackets, those to be expected from a cross-over percentage of 16.4 and 3 : 1 ratios for each of the pairs of characters.

	Early bolters	Late bolters	Total
Multigerm	107 (100)	9 (11)	116 (111)
Monogerm	8 (11)	24 (26)	32 (37)
Total	115 (111)	33 (37)	148

The late-bolting monogerm plants from this progeny were back-crossed to a good strain of Detroit, and the non-bolters will be back-crossed to the same strain in the spring of 1957.

The progeny from the back-cross of the above F_1 to Detroit were all multigerm and early-bolting and were selfed in order to isolate the double recessive, monogerm late-bolting plants to be used in the next back-cross to Detroit.

The progenies described above were raised in the glasshouse ; other progenies of the same parentage were grown in the field for observation of root characters. The quality of monogerm parent stock and of most F_2 plants was very poor, the roots being extremely tough and woody, but those from the first back-cross were of much better quality and more nearly resembled Detroit.

The attempt to produce a non-bolting Detroit type of beet is being made in three ways, one as described above, a second by selection of Detroit under conditions favourable for bolting, and a third by crossing Detroit with a non-bleeding type. This type has good root colour, complete absence of rings and does not bolt when sown early, but it has a long root.

Several varieties classified in the survey of red beet varieties as 'non-bleeding' were used in making the crosses and seed of F_1 hybrids was sown early in 1955 to encourage bolting. The progenies reacted in two ways ; some did not bolt at all in the year of sowing, and others bolted late in the summer, after the plants would have been lifted had they formed a commercial crop ; so that varieties which had been grouped together on morphological grounds could be separated genetically. The late-bolting hybrids were used for making pair-crosses, seed of which was sown in January 1956. The resulting progenies contained a range of root shapes from globe to long and showed continuous bolting throughout the summer instead of the two discrete bolting classes recorded above. A few non-bolting globes were saved for further work.

Spring cabbage (A. G. Johnson and G. J. Faulkner)

Plants selected from varieties found to be superior in previous trials (4) were self-pollinated and crossed in pairs as the beginning of a breeding programme to produce an improved dual-purpose variety. Further plots of these varieties have been grown for selection, including an exceptionally early sowing at the beginning of July, in order to encourage bolting and so make possible more stringent selection against this defect.

Winter cabbage (A. G. Johnson and G. J. Faulkner)

A population of any variety of winter cabbage always contains a number of 'rosette' plants, in which the leaves do not fold over completely to produce a solid head. Selection has failed to remove this defect, and records taken over the past three years have shown that there is a range of forms from the open rosette, in which the leaves do not overlap at all, through grades of overlapping to the normal head. A number of crosses has been made between normal heads and various grades of abnormality, and the resulting progenies suggest that the rosette character is determined by a gene complex. First generation (S_1) inbred lines from apparently normal plants of the variety January King have shown a range from 26 per cent to 60 per cent of

rosette-type heads, and these types have also appeared in hybrids between plants which had normal heads. Attempts will be made to determine the method of inheritance of this defect and also to eliminate it.

Brussels sprouts (A. G. Johnson and G. J. Faulkner)

The inbreeding programme with Brussels sprouts is proceeding in two stages at different rates. Part of the seed produced in each inbred generation is sown in the glasshouse immediately after harvest, in August. The seedlings are given heat when necessary until they reach the 10-leaf stage, after which they are kept in an unheated house until March. Heat is then provided, and they flower in April ; they are selfed and so produce a further inbred generation in one year. In this way the S_3 generation can be reached in three years instead of six and, although this technique precludes selection, it is possible to assess the general effects of inbreeding since this material represents a random sample of the population. The remainder of the inbred seed is grown in the normal way, selecting in each generation only the best lines for further inbreeding. No data are available to show how many generations of inbreeding and selection are necessary for the elimination of the major defects from a Brussels sprout variety of commercial quality, but it is thought that three may be enough.

In 1956 an examination was made of a sample of S_3 lines of Cambridge Special produced by the 'annual' method. The average vigour of these lines was 60 per cent of the original parent. There were striking examples of the segregation of undesirable characters into individual lines, and about one-third of the progenies were considered sufficiently good to be kept for further work. In 1955, test crosses were made between unselected plants from different S_2 lines and the hybrids were grown in the field in 1956. Many of them were poor in quality, as might be expected, but some were very good, and the best one gave 40 per cent more marketable sprouts than the non-inbred nucleus stock from which it was derived. All showed hybrid vigour in varying degree.

S_1 inbred lines from 25 selected plants of Cambridge No. 1 Brussels sprouts were grown in 1956 and compared with progenies produced from the same plants by mass pollination. Variation and inbreeding depression showed the same pattern as that already reported (3) for similar material of Cambridge No. 3. Tests of this kind give an indication of the genotypes of the plants originally selected, and if these plants can be maintained vegetatively until the result of the test is known, those having the poorer genotypes can be discarded and the rest used to produce another crop of seed. An 'elite' stock of Cambridge No. 3 produced in this way by mass pollination of the best 16 of the 39 plants of Cambridge No. 3 described in the 1955 report has given an increase of 35 per cent marketable sprouts over the yield of the stock produced by mass pollination of the 39 plants originally selected.

It was suggested previously (2) that it might be possible to change the breeding system of Brussels sprouts by selecting for self-compatibility. Plants have been selfed for two generations both by pollinating open flowers and by bud-pollination ; the first technique tends to select for self-compatibility, while the second does not. There is, however, in this material no evidence of selection for self-compatibility as a result of self-pollination of open flowers.

Male sterility was found in two inbred lines of Cambridge No. 3 Brussels sprout. A series of test crosses in the variety Cambridge Special has shown the male sterile character to be inherited as a simple recessive.

Early summer cauliflower (L. E. Watts and R. A. T. George)

Inbreeding of Cambridge No. 5 early summer cauliflower was begun in 1954, with the aim of getting an even earlier strain. The first inbred generation has given promising results. Of 14 inbred lines, two commenced curding eight days earlier than the unselected stock and gave as good a yield ; one was three days later than Cambridge No. 5 and the rest were intermediate in maturity. There was little inbreeding depression ; this is to be expected since the early summer cauliflower is self-fertile, though differences between inbred lines suggest that out-pollination occurs.

Onion (H. Holland and G. J. Frost)

Hybrids between American male sterile varieties and Cambridge lines, made in the course of transferring the male sterile character to our material, showed considerable hybrid vigour. The hybrid seedlings emerged two or three days before the parent varieties sown alongside them and gave much better stands from similar seed rates. The hybrid bulbs ripened off earlier and were ready for lifting in the first two weeks of September, despite a very wet August. By the 17th September it was decided to lift the whole crop because of the inclement weather ; at this date only a very few of the hybrids remained unripe, but none of the parents had ripened and they had to be dried artificially indoors. Moreover, the hybrids had not more than 1 per cent bullnecked bulbs, against 90 per cent in the parent varieties. In what had been a bad season for onion growing, the superiority of these hybrids was striking.

It was reported in 1955 (3) that what appeared to be cytoplasmic male sterility had been found in some of our breeding material, and that seed had been produced by pollinating such plants with pollen from a sister plant of the same line. The progeny proved to be superior to the selfed progeny of the male parent in just the same way and to as great a degree as the crosses between varieties described above.

SEED PRODUCTION

Nucleus stock seed was produced of the following varieties which are on the market or are undergoing trials :—

Brussels sprouts	Cambridge Special	At Wellesbourne.
Onion	Cambridge Nos. 2 and 10	At Wellesbourne.
Onion	Cambridge No. 10 at Paglesham.	

The seed crop of Cambridge Red cabbage at Paglesham was killed by the severe frost in February 1956.

Plants were grown for selection and the production in 1957 of nucleus stock seed of the following varieties :—

Brussels sprouts	Cambridge Special at Wellesbourne.	
Winter cauliflower	Cambridge Dwarf April	At Paglesham.
Onion	Cambridge No. 10	At Paglesham.

WORK AT OUTSIDE CENTRES

Trials of new strains of onions were carried out at Efford, Luddington and Stockbridge House E.H.S. and of lettuce breeding material at Luddington. Selections of Roscoff broccoli were again made at Rosewarne E.H.S., and at Luddington facilities were provided for observing the incidence of club root on some cabbage varieties. We are grateful for the ready collaboration of the Directors and staffs of the above E.H.S. We are also indebted to the Director and Mr. Newell of the John Innes Horticultural Institution for the provision of land and assistance in connection with studies on deterioration of Brussels sprout varieties.

MISCELLANEOUS

It has been reported already (1) that plots of different varieties of *B. oleracea* were planted at a number of sites on the Station in order to determine the degree of isolation necessary for seed production in brassica crops. Seed produced by open pollination was collected from the plants in each plot and progenies have been grown and recorded for the occurrence of hybrids. Percentages of hybrids in such progenies have varied from 0.05 per cent to 0.57 per cent, and hybrids have been identified as having been produced between varieties planted as far apart as seven furlongs. While the percentages quoted would have no significance in a commercial crop, they could be of great importance to the producer of pure seed, particularly if the contamination were of the cryptic kind. A more detailed account of this work will appear elsewhere.

A variety of red cabbage produced at the Horticultural Research Station, Cambridge, and tentatively named Cambridge Red, was compared with 15 recommended Dutch and Danish varieties. It proved to be slightly superior to these varieties in both yield and quality, but the margin of superiority was not sufficient to warrant adding yet another variety to the seed catalogues.

Spacing trials with the Brussels sprout variety Cambridge Special have indicated that altering the number of plants per acre can alter the proportion of sprouts in the different size grades without necessarily altering the total yield. A note on this work is being prepared for publication.

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CLASSIFICATION AND PERFORMANCE OF VARIETIES OF RED BEET

By H. HOLLAND

INTRODUCTION

In order to plan a breeding programme with a crop, a knowledge of the existing types and desirable characters of the crop is essential. As a precursor, therefore, to a breeding programme with red beet, a collection of over 200 commercial varieties was grown and studied at the N.V.R.S., Wellesbourne, during the three years 1952-54.

Catalogues of as many as possible of the seed firms in Great Britain were studied, along with those from twelve foreign firms, and seeds of all varieties with different names were obtained. A varietal name prefixed with the name of a seed merchant or grower, e.g. Sutton's Blood Red, was regarded as indicating a different variety. This proved to be of value since it was found that similar named varieties from different merchants did not necessarily belong to the same class, e.g. variety Blood Red ; Sutton's Blood Red belonged to the 'Dwarf Black' class ; Carters Blood Red to the 'Non-bleeding' class ; and Toogood's Blood Red to the 'Covent Garden' class.

Beetroot is normally cross-pollinated and is strongly self-incompatible. Owen (1) has indicated that the self-sterility can be explained as the result of duplicate oppositional factors and has designated them the S and Z series ; corresponding alleles of S and Z are identical in effect but are carried on different chromosomes. Because of this strong mechanism for self-sterility, varieties are extremely heterozygous, and 'synonymous' in the strict sense of the word cannot be used in a varietal classification of red beet unless the breeding history of the varieties is known. With this point in mind, varieties within any particular group in the classification are termed 'near-similars' and not synonyms.

Publications on synonymy and the classification of red beet by Ritchie (2) and the United States Department of Agriculture (3) do not deal with many varieties now available in Britain. Banga (4) made a more precise classification of some flat and globe varieties, on the basis of root index (length/diameter), relative growth rates of foliage and roots, and time of maturity. Owing to the very large number of varieties examined at Wellesbourne it was only possible to base the classification on gross morphological characters, yet the root indices were in good agreement with those of Banga.

All varieties were given a field number and were known only by that number throughout the growing season. The trials were laid out in four randomised blocks of plots. In 1952, the blocks were sown on consecutive days, the first on 29th June. In 1953, the first block was sown in early April, and the other three at monthly intervals. In 1954, the varieties of each class (see under 'classification') were placed in separate trials, for the purposes of yield comparisons within each class, each trial consisting of four randomised blocks. The first blocks of the classes containing flat, globe and intermediate varieties, were sown in mid-April, and the other three blocks of each class were sown at fortnightly intervals. The first blocks of the classes containing long varieties were sown on the same day as the last blocks of the previous classes and the other three blocks were again sown at fortnightly intervals. These different schedules from year to year, and within years, were carried out in order to study the differences in bolting tendency as affected by different sowing dates. The trials were spot sown, each plot consisting of four rows sixteen inches apart, with eight spots per row spaced eight inches apart. The plants were thinned to one per spot as soon after germination as possible, giving 32 plants per plot.

Culture

In the spring of 1952, approximately 30 tons per acre of FYM was ploughed in and no further applications of fertiliser were given in that year. In 1953 and 1954, the trials followed summer cauliflower, after the land had been fallowed until the following

spring. 30 tons per acre of FYM was applied prior to the cauliflower crop and then a single top dressing of 90 lb. nitrogen, 90 lb. phosphate and 150 lb. potash per acre was applied during the preparation of the seedbed for the red beet.

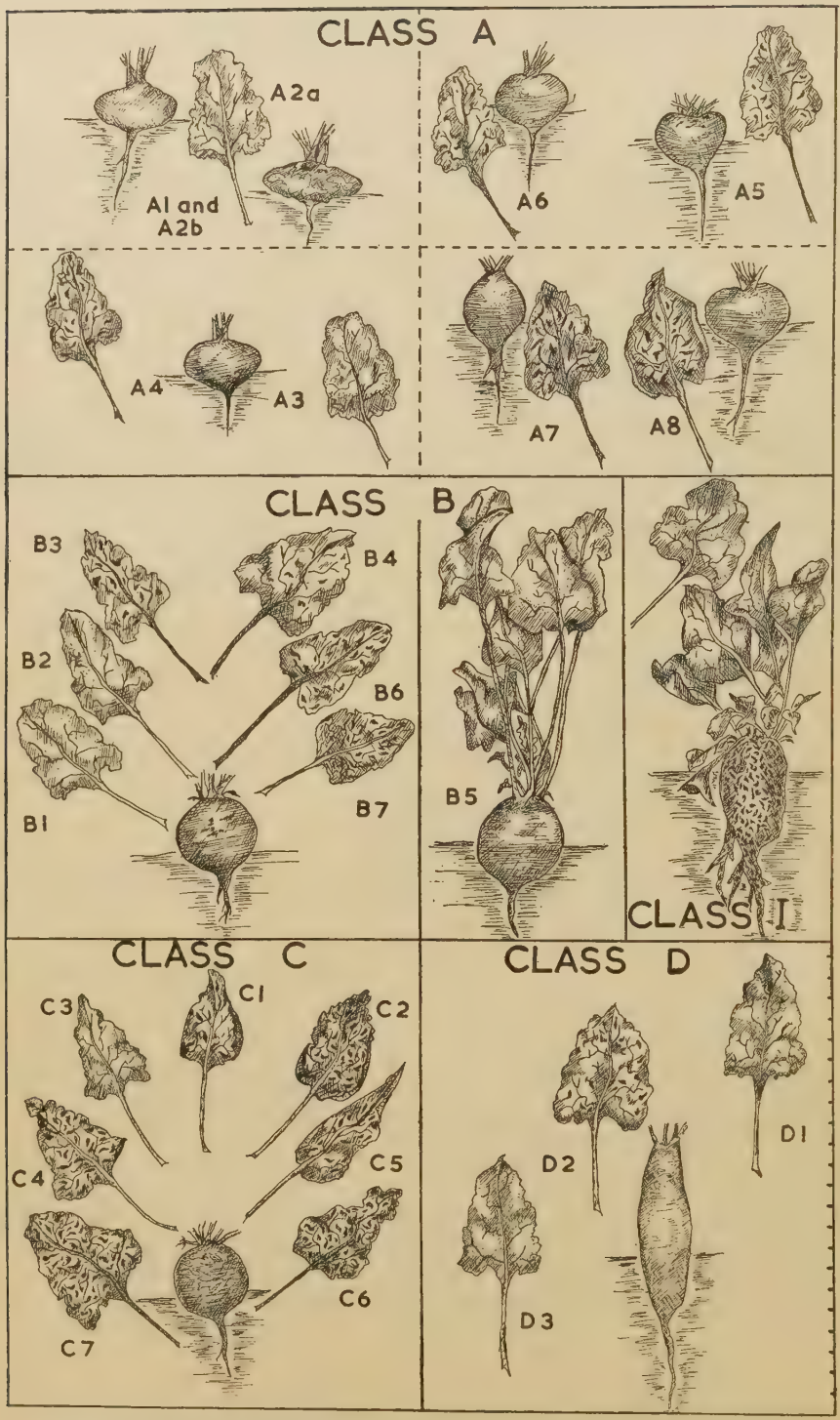
CLASSIFICATION

On the basis of root shape, the varieties tested fell into four distinct categories—Flat, Globe, Intermediate and Long. Two of these categories, Globe and Long, were further sub-divided into two and five classes respectively, giving nine classes in all. The following key gives the characters for class distinction :

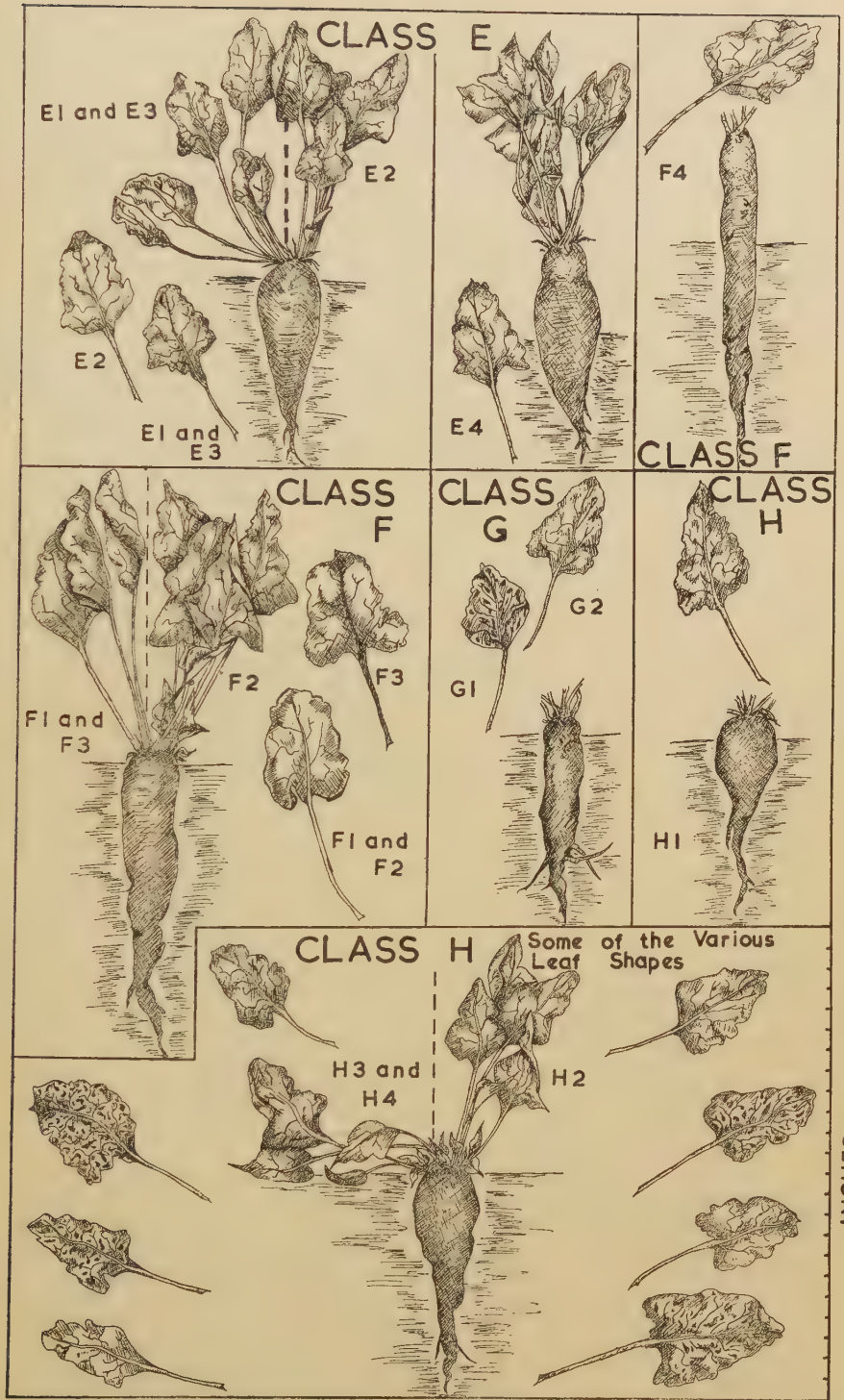
1. Root—flat, oblate, turnip or top-shaped .. Class A (Flat Egyptian types).
2. Root—globe-shaped ; or if oblate, having vermilion internal flesh.
   (a) Foliage medium-tall to tall. Lamina large, thick and ovate ; or fairly large, thick and narrow ovate ; or small, thick and ovate-lanceolate .. .. .. Class B (Egyptian Globe types).
   (b) Foliage dwarf. Slender purple petiole. Lamina medium dark green, lanceolate to ovate-lanceolate with upturned edges **or** bronze petiole with very bullate lamina ±purple suffusion .. .. .. Class C (Detroit Globe types).
3. Root—intermediate or tankard-shaped .. Class D (Intermediate types).
4. Root—long
   (i) Root with smooth skin.
      (a) Foliage dwarf and prostrate. Green lamina with no traces of red or purple at all. Internal flesh of root blood-red to vermilion with indistinct zoning .. Class E (Cheltenham Greentop types).
      (b) Foliage tall and upright. Very vigorous. Thick petiole, large lamina. Root large and very long. Internal flesh dark purple or black with no visible zoning Class F (Non-bleeding types).
      (c) Foliage dwarf. Deep purple or purple/green. Root small and slender. Internal flesh purple usually with distinct zoning .. .. Class G (Dwarf Black types).
      (d) Foliage variable in height and colour. Roots fairly large. Internal flesh purple with distinct zoning .. .. Class H (Covent Garden types).
   (ii) Root with rough skin .. .. .. Class I (Rouge Crapaudine variety).

Each class was then further sub-divided into groups, to give 40 groups in all, according to the following points :

Class A—24 varieties in 8 groups. Classified by leaf thickness and colour and by root ratio (length/diameter).
Class B—17 varieties in 7 groups. Classified by foliage height, colour and shape and, in one case (Group B5), by external and internal root colour.
Class C—105 varieties in 7 groups. Classified by foliage height, shape and colour.
Class D—32 varieties in 3 groups. Classified by foliage height and colour.
Class E—15 varieties in 4 groups. Classified by foliage colour and habit, and by root shape and internal flesh colour.
Class F—29 varieties in 4 groups. Classified by foliage colour and habit, and by root shape.
Class G—13 varieties in 2 groups. Classified by foliage shape, and by root colour.
Class H—28 varieties in 4 groups. Classified by foliage colour, size and habit.
Class I—1 variety only.



Diagrammatic representation of leaf and root characters used for the classification of red beet varieties. Classes A, B, C, D and I. Approx. $\frac{1}{8}$ natural size.



Diagrammatic representation of leaf and root characters used for the classification of red beet varieties. Classes E, F, G and H. Approx. $\frac{1}{8}$ natural size.

Environmental differences had a marked effect on many of the plant characteristics and due regard had to be paid to this in making the classification. Different sowing dates brought about totally different plant features in many of the varieties. The main differences occurred in size, shape and colour of the leaves. With some varieties, early sowing produced a broad and thick leaf lamina and a broad conspicuous blood-red midrib, whilst in later sowings the lamina was narrow and thin, and the midrib was slightly purple. In other varieties, the reverse was the case in that the broad blood-red midrib appeared in later sowings. These irregularities appeared in three classes, the 'Flat Egyptian', the 'Egyptian Globe', and the 'Detroit Globe'.

Some varieties reacted to spells of either cold and wet, or hot and dry weather by an increase in amount of anthocyanin in the leaves, giving a purple colour. Some varieties reacted in this manner to cold and wet spells only, while others reacted to hot and dry spells only. About 22 varieties did not react in either respect.

The effects of weather on root characters were only seen when sowing dates were late in 1952 and 1953 (late June or early July), when hot dry conditions coincided with the flush of growth after the cotyledon stage. Globe and flat varieties were affected and produced turnip-shaped roots having thick coarse tap roots. Presence of undecayed organic matter or gravel had marked effects, especially on the long rooted varieties. Fanging occurred at the point of contact with the manure or gravel thus shortening the potential length of the roots. Some of the above environmental effects on red beet are in agreement with those reported elsewhere (3) and (5).

It will be understood from what has been said above that leaf and root characters may vary in their expression in different years. Most varieties were grown each year from different seed stocks and some 30 of them showed variation in character expression in different years which could not be attributed entirely to environmental effects. Sometimes this necessitated the transfer of a variety from one group to another in the classification and, in a few cases, even from one class to another, e.g. from 'Covent Garden' to 'Dwarf Black'. One of the most striking examples was with two samples of a variety named Rocket. In the first and third years both fell into the Intermediate class but in 1952 they were in one particular group while in 1954 they both fell into another group. In the intervening year, however, one fell into the 'Detroit' class. The group which they formed in 1952 has not occurred since and is therefore not included in the present classification.

Two other outstanding cases occurred and it was not possible to classify the two varieties. The first was a Long Blood Red. In 1952 and 1953 when grown from one stock of seed it proved to be a member of the 'Cheltenham Greentop' class. In 1954, from a new stock of seed, it belonged to a group of the 'Non-bleeding' class. In 1955 from another stock of seed, it was again found to be a member of the 'Cheltenham Greentop' class. The second concerned a variety named Perfection which is not now on the market. It was grown from a fresh stock of seed obtained each year and in 1952 it fell into the 'Cheltenham Greentop' class, whereas in 1953 and 1954 it was found to belong to the 'Covent Garden' class. The above anomalies have been singled out because their peculiar behaviour cannot be explained on the basis of either environmental effect or of selection and must have resulted from seed stocks being wrongly named.

The following is an example, however, where classification was difficult owing to genetic variation. The 'Covent Garden' class was remarkably uniform for root characters but it was also remarkably variable for its foliage characters. Although the range of variation in foliage characters was very wide, these characters were distinct from those in other classes. The 'Dwarf Black' class had remarkably uniform root characters which were almost identical with those of the 'Covent Garden' class, except that the roots were much smaller. The foliage characters of the 'Dwarf Black' class, however, were quite distinct from those of the 'Covent Garden' class in that they were dwarf and of a dark purple colour, and were very uniform for these characters. A few varieties were found which contained plants of the 'Covent Garden' type and also plants of the 'Dwarf Black' type, the proportion of the latter varying in different varieties and in different stocks of the same variety. At the other end of the scale, some

varieties had uniform 'Dwarf Black' plants but different stocks of these varieties could have varying, though relatively small, proportions of 'Covent Garden' plants. It appears, therefore, that these varieties were not pure. While it was easy to separate varieties at the two extremes of the classes, it was difficult to classify those varieties in which the proportion of plants of the two classes were about equal and which were inconsistent in these proportions in different stocks. However, for convenience, such varieties were placed in the 'Covent Garden' class since other varieties in this class also exhibited extreme heterogeneity.

Classified List

In the descriptions that follow, 'early sowing' means early to mid-April and 'late sowing' means late May onwards. Each class is composed of a number of groups of 'near similars' and for easy reference by varietal name, an index is included as an appendix.

Class A. 'Flat Egyptian' types

This class includes true 'Flat Egyptian' types (groups A1-A4) having medium sized thin foliage and flattish, sometimes irregularly lobed roots, and 'Crosby Egyptian' types (groups A5-A8) having more robust foliage and thicker roots. The roots of both types usually have concentric rings of a light colour such as white, lavender or violet. Most are early in maturity.

Key :

1	Leaves green	2
	Leaves purple ± green	Group A8
2	Leaves thin, with thin purple midrib	3
	Leaves thick with broad conspicuous blood-red midrib ...	5
3	Dwarf habit, height 6½-12 inches	Group A1
	Tall habit, height 9½-16½ inches	4
4	Roots flat and lobed. Length/diameter 0.45-0.62	Sub-group A2a
	Roots flat and unlobed. Length/diameter 0.45-0.62	Sub-group A2b
	Roots thick-flat. Length/diameter 0.64-0.75	Group A3
5	Roots thick-flat. Length/diameter 0.55-0.66	Group A4
	Roots deep oblate. Length/diameter 0.58-0.90	6
	Roots top-shaped. Length/diameter 0.65-0.73	Group A7
6	Lamina ovate, length/width 1.09-1.30. Distinct zoning in roots	Group A5
	Lamina ovate-lanceolate, length/width 1.35-1.78. Indistinct zoning in roots	Group A6

Group A1. Foliage dwarf, height 6½-12 inches. Lamina dark to medium green, sometimes lightly stippled purple. Thin, non-bullate with wavy edge. Ovate-lanceolate with slight mucronate tip. Root flat, length/diameter 0.45-0.60, slightly to very lobed, ⅜-¾ above ground. Internal flesh varying shades of purple, with white, lavender, violet or vermilion distinct broad rings. About 86 days with early sowing and 68 days with late sowing to reach two inches diameter. Up to 6 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Egyptian Extra Early	Sharpe	Rouge-noir plate d'Egypte améliorée	Vilmorin (France)

Group A2. Similar to group A1 but larger in most respects. Height 9½-16½ inches. Root flat, length/diameter 0.45-0.62, ⅜-¾ above ground. Same as group A1 for internal flesh and days to reach two inches diameter. Up to 15 per cent bolting when sown early.

Sub-group a. Root lobed, the larger the roots the more prominent and irregular the lobing.

Variety	*Supplier*	*Variety*	*Supplier*
Aegyptische plattrunde	Dippe (Germany)	Egyptian Turnip-rooted	Hurst
Aegyptische plattrunde dunkelrote	S. Müller (Switzerland)	Flat Egyptian	Ste Clothilde (Canada)
Egyptian Extra Early	Arnold		

Sub-group b. Root slightly lobed or not lobed.

Variety	*Supplier*	*Variety*	*Supplier*
Early Flat Egyptian	Asgrow (U.S.A.)	Egyptisk plattrund	Weibull (Sweden)
Egyptian Extra Early	Ohlsens Enke (Denmark)	Flat Egyptian	Agassiz (Canada)
		Rote Rüben Aegyptische	Dippe (Germany)
Egyptian Turnip-rooted	Cooper Taber		

Group A3. Foliage like group A2. Root thick-flat, length/diameter 0.64-0.75, unlobed, ⅜-½ above ground. Same as group A1 for internal flesh and days to reach two inches diameter. Up to 6 per cent bolting when sown early.

Variety	*Supplier*
Egyptian Improved	Ohlsens Enke (Denmark)

Group A4. Foliage medium-tall, height 9½-16½ inches. Lamina medium green, very bullate with broad conspicuous blood-red midrib. Bullateness and colour of midrib can vary a good deal with environment. Root thick-flat, length/diameter 0.55-0.66, ⅜-¾ above ground. Same as group A1 for internal flesh and days to reach two inches diameter. Up to 5 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Ægyptisk fladrund	Daehnfeldt (Denmark)	Egyptian Turnip-rooted	Yates

Group A5. Foliage like group A4. Root deep oblate, length/diameter 0.58-0.90, ½-¾ above ground. Same as group A1 for internal flesh and days to reach two inches diameter. 20-30 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Crosby's	Daehnfeldt (Denmark)	Crosby's	D.L.F. and F.D.B. (Denmark)
		Crosby's Egyptian	Hurst

Group A6. Foliage like group A4 but larger (see key). Root like group A5 in size and shape. Internal flesh deep blood-red with narrow light blood-red rings, sometimes with traces of mauve. About 90 days with early sowing and 70 days with late sowing to reach two inches diameter. Up to 50 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Asgrow Wonder	Asgrow (U.S.A.)	Crosby's	Ohlsens Enke (Denmark)

Group A7. Foliage like group A4. Root top-shaped, length/diameter 0.73-0.97, ½-⅝ above ground. Internal flesh varying shades of purple with white, lavender or light red, distinct broad rings. Same as group A6 for days to reach two inches diameter. Up to 70 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Early Blood Turnip	Asgrow (U.S.A.)	Frühe Wunder	S. Müller (Switzerland)

Group A8. Foliage tall, vigorous, height 14-24 inches. Lamina deep purple, sometimes suffused green. Very bullate with crenate margin. Root turnip-shaped to short top-shaped, length/diameter 0.65-0.76, ⅝ above ground. Internal flesh dark blood-red to purple with white or lavender, very distinct rings. About 93 days with early sowing and 74 days with late sowing to reach two inches diameter. Up to 10 per cent bolting when sown early.

Variety	*Supplier*
Aegyptiske verbesserte dunkellaubige (Khedive)	S. Müller (Switzerland)

Class B. 'Egyptian Globe' types

This is a very mixed class and has been formed for the convenience of the classification. The majority of the varieties have leaves somewhat similar to one or other of the groups of class A (hence the use of 'Egyptian' in the class title), but the roots are globe-shaped and do not show the same distinct 'ringiness' as class A. Second early in maturity.

Key :

1	Foliage light green ± a little purple	2
	Foliage medium green	4
	Foliage dark green ± a little purple, and very bullate	Group B6
	Foliage purple and very bullate	Group B7
2	Internal flesh of root blood-red to purple	3
	Internal flesh of root vermilion to orange-red	Group B5
3	No purple in leaves	Sub-group B4a
	Variable amounts of purple in leaves	Sub-group B4b
4	Leaves very bullate, thick blood-red midrib	Group B3
	Leaves not bullate, purple to pink midrib	5
5	Lamina fairly large, very thin and greyish medium green. Purple in midrib and petiole only	Group B2
	Lamina fairly small and thick with small amounts of purple ...	Group B1

Group B1. Foliage medium-tall, height 6-18 inches. Lamina medium green with small amounts purple suffused. Non-bullate with almost smooth edge. Small, ovate-lanceolate with pronounced mucronate tip. Root globe-shaped, length/diameter 0.88-1.07, ½-¾ above ground. Internal flesh deep blood-red to dark red with narrow indistinct light blood-red rings. Traces of mauve sometimes present. About 90 days with early sowing and 72 days with late sowing to reach two inches diameter. Up to 50 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Barr's Early Red Globe	Barr	Dobbie's Selected Globe	Dobbie
Crimson Globe Selected	Hurst	Spangsbjerg	Ohlsens Enke (Denmark)
Deep Blood Red Globe	Hurst		

Group B2. Foliage medium-tall, height 15-20 inches. Lamina greyish medium green. Narrow ovate, non-bullate, thin with slight wavy edge and small mucronate tip. Root globe-shaped, length/diameter 0.81-1.30, ¼-½ above ground. Internal flesh deep blood-red to light red with narrow, fairly distinct, light red or mauve rings. About 86 days with early sowing and 70 days with late sowing to reach two inches diameter. No bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Green Top Bunching	Ferry Morse (U.S.A.)	Green Top Bunching (Morse)	Tozer

Group B3. Foliage medium-tall, height 9½-16 inches. Lamina medium green, thick, very bullate with broad conspicuous blood-red midrib. Root globe-shaped, length/diameter 0.86-0.93, ½-¾ above ground. Internal flesh deep blood-red with narrow, distinct light blood-red or mauve rings. Same as group B2 for days to reach two inches diameter. 40-70 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Feuerkugel	S. Müller (Switzerland)	Fidler's Model Globe	Fidler
		Perfected Detroit	Asgrow (U.S.A.)

Group B4.

Sub-group a. Foliage medium-tall, height 15-24 inches. Lamina light green. Ovate, slightly bullate with slight wavy edge and conspicuous blood-red midrib. Root globe-shaped, length/diameter 1.0-1.1, ½-¾ above ground. Internal flesh purple to blood-red with narrow, white or violet rings. Same as group B2 for days to reach two inches diameter. Up to 10 per cent bolting when sown early.

Variety	*Supplier*
Tall Top Early Wonder	Ferry Morse (U.S.A.)

Sub-group b. Similar to sub-group B4a, but very variable foliage colour from light green to dark green with small amounts purple in some plants.

Variety	*Supplier*	*Variety*	*Supplier*
Claudia	Otto J. Olson (Sweden)	Spangsbjerg	Daehnfeldt (Denmark)

Group B5. Foliage tall, height 22-24 inches. Lamina light medium green with vein-banding purple in some plants. Thick, large and broad ovate with straight blood-red midrib. Root globe-shaped or oblate, length/diameter 0.78-1.06, ½ above ground. Internal flesh bright red or vermilion with white or mauve, distinct broad rings. Same as group B2 for days to reach two inches diameter. Up to 70 per cent bolting when sown early.

Variety	*Supplier*
Eclipse	Asgrow (U.S.A.)

Group B6. Foliage medium-tall, height 14-20 inches, semi-upright. Lamina dark green, slight suffusion purple in some plants. Thick, ovate and very bullate with conspicuous, thick, blood-red midrib bent downwards near apex. Root globe-shaped, length/diameter 1.00-1.20, ½ above ground. Internal flesh dark to light blood-red with white or violet narrow rings. Same as group B2 for days to reach two inches diameter. Up to 50 per cent bolting when sown early.

Variety	*Supplier*
Fire Ball	Ohlsens Enke (Denmark)

Group B7. Foliage like B6 but totally deep purple with dull green tinges in some. Root globe-shaped, length/diameter 0.87-1.02, ½ above ground. Internal flesh purple to blood-red with distinct broad rings of varying colours such as light blood-red, violet, mauve, lavender and white. About 90 days with early sowing and 75 days with late sowing to reach two inches diameter. Up to 40 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Runde schwarzrote dunkellaubige	S. Müller (Switzerland)	Runde, sortrød, mørkløvet	Daehnfeldt (Denmark)

Class C. 'Detroit Globe' types

This class includes the most popular kinds of red beet. The foliage is small to medium sized, and the roots globe-shaped having dark red internal flesh, usually with inconspicuous zoning of a lighter red than the background. They are second early in maturity, suitable for early sowing with a risk of premature seeding, or for later sowing for storage or pickling.

Banga (4) divides Detroit varieties firstly into three groups on the length/diameter ratio of the root ; 0.81-0.90 ; 0.91-1.00 and greater than 1.00. In the trials at Wellesbourne, a range of root ratios from 0.84-1.12 was obtained but no division of it could be made statistically using the Duncan test (6). However, the root ratios of any particular variety, for each year it was grown, were fairly constant and so were characteristic of the variety. The average root ratio for each variety for the three years of the trials is given below in the classification. Comparisons can thus be made between varieties.

Key :

1	Lamina with purple to pinkish midrib	2
	Lamina with broad blood-red midrib	Group C7
	Lamina with bronze midrib and sometimes small amounts of purple. Root with no visible rings	Group C6
2	Lamina ovate-lanceolate. Length/width 1.33-1.76	3
	Lamina long and narrow. Length/width 1.71-2.15	Group C5
3	Dwarf to medium-tall. Height 6-16 inches (average 12) semi-rosetted	4
	Fairly tall. Height 8-20 inches (average 16) almost upright ...	Group C4
4	Lamina not bullate	Group C3
	Lamina very bullate	Group C2
	Lamina slightly bullate	Group C1

Group C1. Foliage medium-tall to dwarf, height 6-16 inches, semi-rosetted. Lamina medium green rarely flecked purple, pink or purple veins. Ovate-lanceolate, slightly bullate with crenate edge. Slightly bent downwards near apex and basal edges upturned. Root globe-shaped, length/diameter 0.84-1.12, ½-⅝ above ground. Internal flesh dark blood-red, dark red or purple with narrow, lighter red, indistinct rings.

Traces of mauve sometimes present. About 86 days with early sowing and 70 days with late sowing to reach two inches diameter. Up to 75 per cent bolting when sown early.

Variety	*Supplier*	*Average root ratio*
Blood Red Globe	Dicksons (*Hawlmark*)	1.01
Blood Red Globe	Dunn	0.98
Blood Red Globe	Woodheads	0.97
Cannells' Blood Red Globe	Cannells	0.97
Cannells' Little Nigger	Cannells	1.00
Carters Crimson Ball	Carters	0.93
Clibrans' Black Knight Globe	Clibrans	0.98
Clibrans' Selected Red Globe	Clibrans	0.95
Cluseed Empire Globe	Clucas	1.01
Cooper's Market Wonder Globe	Cooper Taber	1.11
Crimson Gem	D. T. Brown	1.00
Crimson Globe, Early	Johnson	1.01
Crimson Globe Select	Speed	0.98
Crimson King	Ohlsens Enke (Denmark)	1.01
Crimson King	Speed	0.98
Crimson King Globe	Sharpe	0.90
Croll's Crimson Ball	Croll	1.01
Cundy's Perfect Globe	Cundy	1.05
Cundy's Selected Early Model Crimson Globe	Cundy	—
C.W.S. King of the Globe	C.W.S.	0.94
C.W.S. Selected Crimson Globe	C.W.S.	0.93
Daniels' Crimson Monarch	Daniels	0.94
Detroit	Cooper Taber	0.96
Detroit	S. Müller (Switzerland)	0.94
Detroit	Ohlsens Enke (Denmark)	0.94
Detroit Dark Red (Ferry's strain)	Ferry Morse (U.S.A.)	—
Detroit Dark Red (Morse's strain)	Ferry Morse (U.S.A.)	0.93
Detroit No. 6	Manitoba (Canada)	1.02
Detroit No. 26	Manitoba (Canada)	0.96
Detroit Select Globe	Hurst	0.98
Dickson, Brown & Tait's Carrington Perfection	Dickson, Brown & Tait	0.96
Dickson's Dark Red Globe	Little & Ballantyne	0.99
Dobies' Crimson Globe	Dobies (*Chester*)	0.93
Dunns Perfection Globe	Dunns	0.91
Early Model	Bunting	0.98
Early Red Globe Select	Yates	0.98
Early Round	Webb (*Kendal*)	0.82
Empire Globe	Woodwards	1.02
E.W.K.'s Blood Red Globe	E. W. King	0.99
E.W.K.'s Crimson Globe	E. W. King	0.92
Finney's Model Globe	Finney	0.96
Finney's Ruddigore	Finney	0.96
Fireball	Bunting	0.84
Fogwills Crimson Beauty	Fogwills	1.02
Fogwills New Dark Red Globe	Fogwills	0.90
Good for All	Hurst	1.00
Good for All	Speed	0.83
Good for All	Weibull (Sweden)	0.96
Harrisons' Early Wonder	Harrisons (*Leicester*)	0.90
Harrison's Summer Globe	Harrison (*Maidstone*)	1.03
Imperial Early Globe	D. T. Brown	1.02
Johnson's Perfect Globe	Johnson	1.03
Kelway's Perfect Model Globe	Kelway	1.01
Kelway's Perfect Model Globe	Sharpe	1.13
Laxton's Crimson Ball	Laxton	0.89
Leightons Crimson Globe	Leightons	0.94
Market Wonder Globe	Fidler	1.04
Model Early Red Globe	D. T. Brown	1.03
Müller's Beste von Allen	S. Müller (Switzerland)	0.87
Perfection Globe	Dicksons (*Hawlmark*)	1.11
Rouge-noir ronde hâtive	Vilmorin (France)	0.87
Round Red	Van den Berg (Netherlands)	0.80
Ruby Red	Webb (*Kendal*)	0.98
Ruddigore	Woodwards	0.96
Ryders' Crimson Ball	Ryders	0.97
Speed's Early Perfection Globe	Speed	1.02
Sutton's Globe	Sutton	0.93
The Cooper Taber	Cooper Taber	0.98
Toogood's Blood Royal Globe	Toogood	0.99
Toogood's Earliest of All Globe	Toogood	0.94
Webbs' Crimson Epicure	Webbs (*Stourbridge*)	0.99
Webbs' Reliance Globe	Webbs (*Stourbridge*)	0.97
Woodwards Vulcan Reselected	Woodwards	0.99
Yates' Fireball	Yates	0.92
Yates' Benefactor	Yates	0.98

Group C2. Differs from group C1 in having foliage very bullate, giving appearance of slightly deeper green. This character has not been present every year.

Variety	*Supplier*	*Average root ratio*	*Variety*	*Supplier*	*Average root ratio*
Crimson King	Cundy	0.95	Harrisons' Special Short Top	Harrisons (*Leicester*)	0.98
Daniels' Acquisition	Daniels	0.97	L. & B.'s Model Red Globe	Little & Ballantyne	1.02
Early Model Red Globe	Speed	1.00	Ryders' July Globe	Ryders	0.95
Early Wonder	Speed	0.98			
Fogwills Earliest of All	Fogwills	0.98			

Group C3. Differs from group C1 in having foliage non-bullate and dull green with greyish tinge.

Variety	*Supplier*	*Average root ratio*	*Variety*	*Supplier*	*Average root ratio*
Arnold's Red Globe	Arnold	0.98	Feltham Globe	Watkins & Simpson	0.95
Daniels' Model Globe	Daniels	0.95			

Group C4.

Sub-group a. Slightly larger than group C1 in all respects. Foliage very bullate giving appearance of slightly darker green.

Variety	*Supplier*	*Average root ratio*	*Variety*	*Supplier*	*Average root ratio*
Cannells' Ebony Globe	Cannells	0.96	Harrisons' Early Green Top	Harrisons (*Leicester*)	0.80
Green Top Early Wonder	Ferry Morse (U.S.A.)	1.01	Red Ball	Ohlsens Enke (Denmark)	1.06
			Woodheads Perfecta	Woodheads	0.97

Sub-group b. Similar variety, but slightly lighter green foliage than C1.

Variety	*Supplier*
Beet, Early Crop	Harrison (*Maidstone*)

Group C5. Differs from group C1, in having lamina long and narrow. Up to 20 per cent bolting when sown early.

Variety	*Supplier*	*Average root ratio*
Sigma	Ohlsens Enke (Denmark)	0.99

Group C6. Foliage similar to group C4 in size. Lamina very bullate, green with varying amounts purple up to 50 per cent. Bronze to deep red petioles on adaxial surface. Root globe-shaped, ½ above ground. Internal flesh very deep red with no rings visible. Very susceptible to apical mildew. 100 per cent bolting when sown early, up to 75 per cent with May sowing and about 20 per cent with June sowing.

Variety	*Supplier*	*Average root ratio*
Detroit No. 16	Ottawa (Canada)	1.00

Group C7. Differs from group C1 in having thick conspicuous blood-red midrib. This group has sometimes been exactly like group C1 but at other times has had the conspicuous blood-red midrib characteristic of group A4.

Variety	*Supplier*	*Average root ratio*	*Variety*	*Supplier*	*Average root ratio*
Bees' Crimson Globe	Bees	0.99	Pennells' Selected Detroit	Pennells	0.93
Bunting's New Blood Red Globe	Bunting	0.90	Rote Kugel	Dippe (Germany)	0.92
Detroit	Daehnfeldt (Denmark)	0.94	Sharpe's Extra Selected Crimson Globe	Sharpe	0.98
Elsoms Crimson Globe Select	Elsoms	0.97	The King Globe	J. K. King	0.96
Exhibition Globe	Woodheads	0.98	Tonkin's Deep Blood Red Globe	Tonkin	0.96
Pennells' Ruby Globe	Pennells	0.97			

Class D. 'Intermediate' types

These types have tankard-shaped roots ½-¾ above the ground with fairly small foliage. The internal flesh colour is usually poor, having conspicuous rings of a white, mauve or lavender colour. They are suitable for harvest when about 1½ inches in diameter, and are second early. If allowed a long growing season, the roots become very large and coarse.

Key :

1	Foliage small, height 9-22 inches	2
	Foliage large, height 12-26 inches	3
2	Lamina medium green only	Sub-group D1a
	Lamina medium green with small amounts of purple	Sub-group D1b
3	Lamina medium green. Internal colour of root purple to blood-red with very distinct zoning	Group D2
	Lamina shiny dark green. Internal colour of root blood-red to dark blood-red with indistinct zoning	Group D3

Group D1. Root tankard-shaped, length/diameter 1.41-3.30, ½-¾ above ground. Internal flesh blood-red, scarlet or purple with white, mauve or lavender, broad distinct rings. About 86 days with early sowing and 68 days with late sowing to reach 1½ inches diameter. Up to 30 per cent bolting when sown early.

Sub-group a. Foliage small, semi-upright, height 9-22 inches. (About ⅓-½ of this accounted for by above-ground portion of root.) Lamina shiny, medium green. Fairly small, ovate and non-bullate.

Variety	*Supplier*	*Variety*	*Supplier*
Arnold's Intermediate	Arnold	Leightons Intermediate	Leightons
Bees' Intermediate	Bees	New Intermediate	J. K. King
Croll's Acquisition	Croll	Nonpareil	Cooper Taber
Elsoms Early Intermediate	Elsoms	Obelisk	Daehnfeldt (Denmark)
E.W.K.'s Intermediate	E. W. King	Obelisk	Hurst
Feltham Intermediate	Watkins & Simpson	Rocket Intermediate	Yates
Finney's Selected Intermediate	Finney	Rocket	Speed
		Ryders' New Oval	Ryders
Fogwills New Intermediate	Fogwills	The Beesian Beet	Bees
		Toogood's Sultan	Toogood
Hawlmark Intermediate	Dicksons (*Hawlmark*)	Unwins Intermediate	Unwins
		Webbs' Intermediate	Webbs (*Stourbridge*)
Kelway's Kitchener Intermediate	Kelway	Woodwards Improved Nonpareil	Woodwards
L. & B.'s New Oval	Little & Ballantyne		

Sub-group b. Foliage like sub-group D1a but leaves suffused with small amounts purple.

Variety	*Supplier*	*Variety*	*Supplier*
Carters New Intermediate	Carters	Daniels' Intermediate Red	Daniels
C.W.S. Intermediate	C.W.S.		

Group D2. Foliage like sub-group D1a, but slightly more robust, height 12-26 inches. Root like group D1.

Variety	*Supplier*	*Variety*	*Supplier*
Nonsuch	D. T. Brown	Obelisk or Nonpareil	Woodwards
Obelisk	Little & Ballantyne		

Group D3. Foliage like group D2 but slightly darker green and shiny. Slight suffusion red in some plants. Root size and shape as group D1. Internal flesh deep blood-red with white to mauve narrow rings.

Variety	*Supplier*	*Variety*	*Supplier*
Clucas' Excelsior	Clucas	Harrison's Perfectus	Harrison (*Maidstone*)

Class E. 'Cheltenham Greentop' types

In this class, the foliage is entirely green with no traces at all of red or purple. The roots are long, conical and smooth, light blood-red in colour (one exception), usually with inconspicuous rings. Very suitable for winter storage.

Key :

1	Root, shoulders only above ground	2
	Root, half above ground	Group E4
2	Internal colour of root light blood-red	3
	Internal colour of root dark blood-red, indistinct zoning ...	Group E3
3	Leaves shiny medium green, upright habit. Pink petioles ...	Group E2
	Leaves dull medium green, rosetted habit. Green petioles ...	Group E1

Group E1. Foliage dwarf, rosetted, height 5½-16 inches. Lamina dull medium green with small white hairs on upper surface and along veins only on lower surface. Broad ovate, non-bullate with pronounced mucronate tip. Root long conical, length/diameter 2.38-2.68, shoulders only above ground. Internal flesh blood-red to light blood-red with narrow inconspicuous lighter red rings. About 90 days with early sowing and 75 days with late sowing to reach 1½ inches diameter. No bolting when sown early.

Variety	*Supplier*
Cheltenham Greentop Selected	Hurst
Cheltenham Greentop Selected	Yates
Cooling's Omega	Cooper Taber
Cundy's Extra Selected Cheltenham Greentop	Cundy
E.W.K.'s Selected Cheltenham Green-leaved	E. W. King
Greentop Beet	Webbs (*Stourbridge*)
Harrisons' Cheltenham Green-leaf	Harrisons (*Leicester*)
Harrison's Improved Cheltenham Greentop	Harrison (*Maidstone*)
King of the Market	Fogwills
Sutton's Greentop	Sutton

Group E2. Differs from group E1 in having upright foliage with lamina bright green, very glossy and non-hairy.

Variety	*Supplier*
Cheltenham Vigour	Tozer

Group E3. Differs from group E1 in having greyish tinge on lamina, sometimes flecked pink, and in having root deep blood-red with no visible rings. Susceptible to mildew. 1 or 2 per cent bolting when sown early.

Variety	*Supplier*
Long Red Green-leaved	Van den Berg (Netherlands)

Group E4. Foliage like group E2. Root long, length/diameter 2.41-3.30, ½-⅔ above ground. Internal flesh light red to vermilion with only slight traces of lighter rings. Brittle and easily broken. About 86 days with early sowing and 68 days with late sowing to reach two inches diameter. No bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Clibrans' Exhibition Black Long	Clibrans	Cobham Early	Tozer
		Cooks' Delight	Chase

Class F. 'Non-bleeding' types

Varieties in this class have very tall foliage, large leaves and thick upright petioles. The roots are very long, deep purple or almost black in internal colour with no visible rings. They should be sown late (June) and can be stored for use during the winter. The roots can be cut before cooking without the risk of losing colour through bleeding.

Key :

1	Root, totally below ground, or shoulders only above ground ...	2
	Root, half above ground	Group F4
2	Leaves entirely green. Conspicuous blood-red midrib. Mildew resistant	Group F3
	Leaves entirely green. Mildew susceptible. Many small axillary leaves	Group F2
	Leaves green stippled small amounts of purple. Mildew susceptible	Group F1

Group F1. Foliage very large and robust, height 10-26½ inches. Petiole very thick and upright. Lamina medium green suffused and stippled small amounts purple. Broad ovate, thick and very bullate, edges folding backwards. Apical leaves susceptible to mildew. Root very long, length/diameter 3.00-5.04, totally below ground. Numerous thick fleshy side roots. Internal flesh very deep purple to almost black with no visible rings. When allowed a long growing season, becomes very large and coarse. No bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Arnold's Blood Red	Arnold	Dobies' Purple	Dobies (*Chester*)
Bell's Deep Blood Red	Dickson, Brown & Tait	Finney's Exhibition Black	Finney
Best of All, Sharpe's	Sharpe	Fogwills Black	Fogwills
Carters Blood Red	Carters	L. & B.'s Exhibition Black	Little & Ballantyne
Clibrans' Non-bleeding Deep Blood Red	Clibrans	Non-bleeding Deep Blood Red	Little & Ballantyne
Croll's Exhibition Blood Red	Croll	Veitch's Superb Red	Hurst
Dobbie's Purple Beet	Dobbie (*Edinburgh*)	Webbs' Volunteer	Webbs (*Stourbridge*)
Dobbie's New Purple	Dickson, Brown & Tait		

Group F2. Similar to group F1, but leaves entirely bright green with no purple. More vigorous than group F1 with many small axillary leaves in axils of main leaves. Sometimes members of this group indistinguishable from group F1. Susceptible to mildew. No bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Bell's Galloway Purple	Laxton	Non-bleeding	Finney
Bell's Non-bleeding	E. W. King	Non-bleeding	Fogwills
Dobbie's Purple	Cooper Taber	Non-bleeding Purple	Alexander & Brown
Goldie's Superb Black	Finney	Sutton's Black	Sutton

Group F3. Same size and habit as group F1 but lamina does not fold back at edges. Bright green with broad conspicuous blood-red midrib. Not susceptible to mildew. No bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Black Queen	Dicksons (*Hawlmark*)	Rouge Foncé de Massy	Vilmorin (France)

Group F4. Foliage similar to group F1 but semi-upright and slightly smaller. Lamina olive green with no traces of purple. Not susceptible to mildew. Root very long and slender, length/diameter 3.25-6.10, ½ above ground. Internal flesh very dark purple with no visible rings. About 10 per cent bolting when sown early.

Variety	*Supplier*	*Variety*	*Supplier*
Lang rote	Dippe (Germany)	Long Dark Blood (above ground)	Ferry Morse (U.S.A.)
Lang sortrød forbedret	Daehnfeldt (Denmark)	Rouge-noir longue des vertus	Vilmorin (France)

Class G. 'Dwarf Black' types

The plants show dwarf habit and usually have deep purple leaves. The roots are small, long and slender with white or violet conspicuous rings (one exception).

Key :

1	Leaves broad on thick petiole. Internal colour of root purple with very distinct zoning	2
	Leaves narrow on slender petiole. Internal colour of root purple with indistinct zoning	Group G2
2	Lamina totally purple. Dwarf habit	Sub-group G1a
	Lamina varying amount of green and purple. Dwarf habit ...	Sub-group G1b
	Lamina varying amount of green and purple. Tall habit ...	Sub-group G1c

Group G1. Root long, fairly small, length/diameter 2.45-3.61, totally below ground. Internal flesh blood-red sometimes tinged violet, with violet or white, narrow distinct rings. No bolting when sown early.

Sub-group a. Foliage dwarf, upright to slightly spreading, height 5½-20 inches. Lamina deep shiny purple, with short grey hairs scattered on lower surface and sometimes a few on upper surface. Small, blunt ovate and slightly bullate with small mucronate tip. Basal edges folded upwards.

Variety	*Supplier*	*Variety*	*Supplier*
Arnold's Black	Arnold	Howcroft's Blood Red	Cooper Taber
Dell's Crimson	Finney	Kelway's Choice Dwarf Dark or Crimson Gem	Kelway
Dicksons' Paragon	Dicksons (*Hawlmark*)		
Dickson's Superb Dwarf Top Black	Dickson, Brown & Tait	Sutton's Blood Red	Sutton

Sub-group b. Differs from sub-group a in having foliage variable combinations of purple and green from pure olive green to pure deep purple. Sometimes indistinguishable from sub-group a.

Variety	*Supplier*	*Variety*	*Supplier*
Carters Perfection	Carters	Pragnell's Exhibition	Dicksons (*Hawlmark*)

Sub-group c. Differs from sub-group a in having variable colour of foliage and being slightly taller, height 10-22½ inches. This group also sometimes indistinguishable from sub-group a.

Variety	*Supplier*	*Variety*	*Supplier*
Dicksons' Epicure	Dicksons (*Hawlmark*)	Fidler's Blood Red	Fidler
		Nutting's Dwarf Red	Cooper Taber

Group G2. Foliage upright and medium-tall, height 12-22 inches. Lamina lanceolate, slightly bullate and purple, suffused green up to 50 per cent. Root similar to group G1 but with no visible rings. Traces of mauve sometimes present.

Variety	*Supplier*
Non plus ultra	Van den Berg (Netherlands)

Class H. 'Covent Garden' types

Except for group H1, all varieties in this class are very heterogeneous, with varying leaf colours and plant habits. The roots are long, conical and fairly uniform, of poor colour with prominent violet or white rings.

Key :

1	Foliage uniform, dwarf. Small narrow purple lamina with green veins and midrib	Group H1
	Foliage not uniform or, if fairly uniform, tall	2
2	Foliage tall, all upright. Slightly bullate	Sub-group H2a
	Foliage tall, some plants upright, some rosetted. Slightly bullate	Sub-group H2b
	Foliage dwarf, very rosetted or semi-rosetted	3
3	Foliage very rosetted and non-bullate	4
	Foliage semi-rosetted, bullate or very bullate	5
4	Foliage purple±green up to about 50 per cent	Sub-group H3a
	Foliage grey-green. No red or purple	Sub-group H3b
	Foliage silver-green±small amounts of red and/or purple ...	Sub-group H3c
5	Foliage slightly bullate, small lamina	Sub-group H4a
	Foliage very bullate, large lamina	Sub-group H4b

Group H1. Foliage dwarf, height 6-12 inches, semi-rosetted. Lamina shiny purple, midrib and side veins green to greenish purple. Small, slightly bullate, edges curving backwards. Root long, length/diameter 2.30-2.80, round shoulders above ground. Internal flesh purple to blood-red with violet or mauve narrow rings. No bolting when sown early.

Variety	*Supplier*
Pennells' Superb	Pennells

Group H2. Root long, length/diameter 2.28-3.06, round (sometimes flat) shoulders above ground. Internal flesh purple with conspicuous white, mauve or violet rings. Up to 5 per cent bolting when sown early.

Sub-group a. Foliage tall mainly, height 16-18 inches. Lamina shades of grey-green suffused red.

Variety	*Supplier*	*Variety*	*Supplier*
Cooper's Market King	Cooper Taber	Ryders' Blood Red	Ryders
Cundy's Select Dwarf Red	Cundy	Speed's Selected Covent Garden	Speed
C.W.S. Blood Red	C.W.S.		

Sub-group b. Similar to sub-group H2a but larger leaf. Taller, 22 inches, upright and rosetted.

Variety	*Supplier*	*Variety*	*Supplier*
Barr's Covent Garden	Barr	Middleton Park Favourite	Speed
Covent Garden Red	Woodwards	Toogood's Blood Red Long	Toogood
Dell's Black-leaved	Hurst	Yates' Exhibition Blood Red	Yates
E.W.K.'s Select Dark Red	E. W. King		
Laxton's Exhibition	Laxton		

Group H3. Root like group H2.

Sub-group a. Foliage dwarf, rosetted, height 4-8 inches. Lamina varying from half green/half purple to totally purple. Ovate, non-bullate.

Variety	*Supplier*	*Variety*	*Supplier*
Dewar's Northumberland	Sharpe	Improved Long Dark Red	J. K. King
Elsoms Select Long Red	Elsoms	Nutting's Select Dwarf	Clibrans
Exhibition Crimson Long	Unwins	Reine des Noires	S. Müller (Switzerland)
Finney's Northumberland	Finney	Select Long Blood Red	Yates
		Toogood's Crimson King	Toogood

Sub-group b. Similar to sub-group H3a but no purple. Grey-green leaves.

Variety	*Supplier*
Exhibitor	Alexander & Brown

Sub-group c. Foliage silver-green, with up to 50 per cent red. Non-bullate, small ovate and very rosetted.

Variety	*Supplier*
Arnold's Market Favourite	Arnold

Group H4. Root like group H2.

Sub-group a. Foliage differs from sub-group H3a in being semi-upright, height about 14 inches. Slightly bullate.

Variety	*Supplier*
Nutting's Select Red	Hurst
Webbs' Improved Dark Red	Webbs (*Stourbridge*)

Sub-group b. Similar to sub-group H2a. Slightly larger foliage and very bullate. Lamina long ovate.

Variety	*Supplier*
Harrison's Prize	Harrison (*Maidstone*)

Class I. Rouge Crapaudine

Foliage medium-tall, height 10-21 inches. Lamina bright shiny green slightly stippled light purple. Midrib and major side veins white or greenish-white, bent sideways and downwards thus distorting leaf. Slightly bullate with edges folded upwards. Root long to half long, length/diameter 2.23-2.89, totally below ground.

Epidermis rough and warty. Many thick fleshy side roots. Internal flesh violet-red with violet narrow conspicuous rings. No bolting when sown early.

Variety	*Supplier*
Beta Rouge Crapaudine	Vilmorin (France)

Yield performance

The data for the 1954 yield trial, together with the bolting data for 1953 and 1954, are given in Tables I-VIII. Twenty roots from each plot were taken at random and weighed. In the first sowings of Classes B and C, nearly all the varieties had less than twenty marketable roots left at harvest, the remainder having produced seed stalks ; this occurred also with a few varieties in Classes A and D. In such instances, the number and weight of marketable roots were recorded, the weight later being adjusted on a twenty-root basis. The analyses of the mean root weights were carried out by the 'New multiple range test' suggested by Duncan (6), and the varieties printed in heavy figures were not significantly different from the highest yielder in each class at the five per cent level. Since adjustments were made to the yield data from the early sowings of many varieties in Classes A, B, C and D, the mean weights per twenty roots given in the Tables for these classes are not true reflections on total yields for early sowing. An indication of marketable yield from early sowings can be obtained from the percentage of non-bolters and the mean root weight, whilst the mean weights themselves are indicative of total yields for later sowings when premature bolting is negligible. Group and sub-group mean weights were analysed separately and the results are given below each Table. Mean root weights not underscored by the same line **are** significantly different, and mean root weights underscored by the same line **are not** significantly different, significance being at the five per cent level of probability.

TABLE I

Class A. 'Flat Egyptian' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown		Late sown	
			1953	1954	1953	1954
A1	Egyptian Extra Early	**29.1**	17	3	0	0
	Rouge-noir plate d'Égypte améliorée...	20.8	0	6	0	0
A2a	Aegyptische plattrunde	19.8	0	9	0	0
	Aegyptische plattrunde dunkelrote ...	21.6	0	6	0	0
	Egyptian Extra Early	21.9	0	3	0	0
	Egyptian Turnip-rooted	**27.4**	3	12	0	0
	Flat Egyptian	22.4	0	3	0	0
A2b	Early Flat Egyptian	23.5	9	25	0	3
	Egyptian Extra Early	21.1	0	9	0	0
	Egyptian Turnip-rooted	**25.0**	0	9	0	0
	Egyptisk plattrund	**24.4**	0	3	0	0
	Flat Egyptian	**25.8**	3	12	0	0
	Rote Rüben Aegyptische	**24.0**	—	6	—	0
A3	Egyptian Improved	21.6	—	3	—	0
A4	Ægyptisk fladrund	**26.9**	0	3	0	0
	Egyptian Turnip-rooted	**25.4**	0	3	0	0
A5	Crosby's	**28.1**	0	6	0	0
	Crosby's	not grown	—	—	—	—
	Crosby's Egyptian	22.4	5	31	0	0
A6	Asgrow Wonder	**29.4**	25	43	3	3
	Crosby's	**29.6**	—	12	—	0
A7	Early Blood Turnip	22.1	50	72	9	21
	*Frühe Wunder	**24.3**	3	9	0	0
A8	Aegyptische verbesserte dunkellaubige (Khedive)	19.8	0	9	0	0

Mean weight : s.e. for a difference between two means of varieties = ±2.36 lb.

Group	A8	A3	A7	A2	A1	A5	A4	A6
Mean root weight ...	19.8	21.6	23.2	23.3	25.0	25.3	26.2	29.5

*Owing to an error in recording the yield of one plot of this variety, a missing plot value has been substituted.

TABLE II

Class B. 'Egyptian Globe' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown		Late sown	
			1953	1954	1953	1954
B1	Barr's Early Red Globe	**25.4**	0	15	0	0
	Crimson Globe Selected	**26.6**	3	56	3	3
	Deep Blood Red Globe	**27.9**	0	40	0	0
	Dobbie's Selected Globe	**27.0**	20	44	0	0
	Spangsbjerg	**30.6**	0	50	0	0
B2	Green Top Bunching	**26.0**	—	0	—	0
	Green Top Bunching (Morse) ...	**28.4**	—	0	—	0
B3	Feuerkugel	**26.5**	10	44	3	3
	Fidler's Model Globe	**22.3**	20	47	0	0
	Perfected Detroit	**21.1**	25	75	9	9
B4	Tall Top Early Wonder	**29.3**	—	15	—	0
	Claudia	not grown	3	—	0	—
	Spangsbjerg	not grown	3	—	0	—
B5	Eclipse	**30.5**	12	72	3	3
B6	Fire Ball	**28.6**	—	53	—	0
B7	Runde schwarzrote dunkellaubige ...	**23.0**	5	40	0	0
	Runde, sortrød, mørkløvet	not grown	3	—	0	—

Mean weight : s.e. for a difference between two means of varieties = ±3.55 lb.

Group	B7	B3	B2	B1	B6	B4	B5
Mean root weight ...	23.0	23.3	27.2	27.5	28.6	29.3	30.5

TABLE III

Class C. 'Detroit Globe' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown		Late sown	
			1953	1954	1953	1954
C1	Blood Red Globe	16.9	3	15		
	Blood Red Globe	**22.1**	3	25		
	Blood Red Globe	**23.1**	10	44		
	Cannells' Blood Red Globe	not grown	—	—		
	Cannells' Little Nigger	not grown	—	—	N	N
	Carters Crimson Ball	**23.1**	10	62		
	Clibrans' Black Knight Globe ...	16.6	0	19	O	O
	Clibrans' Selected Red Globe ...	**23.8**	3	53		
	Cluseed Empire Globe	**22.5**	3	44		
	Cooper's Market Wonder Globe ...	**24.3**	20	72		
	Crimson Gem	**25.4**	10	59	B	B
	Crimson Globe	**24.0**	10	28	O	O
	Crimson Globe Select	20.5	14	56	L	L
	Crimson King	**24.6**	15	65	T	T
	Crimson King	not grown	10	—	I	I
	Crimson King Globe	not grown	14	—	N	N
	Croll's Crimson Ball	**24.3**	—	56	G	G
	Cundy's Perfect Globe	19.0	—	44		
	Cundy's Selected Early Globe ...	18.1	—	22		
	C.W.S. King of the Globe	**27.0**	14	22		
	C.W.S. Selected Crimson Globe ...	**23.6**	14	25		
	Daniels' Crimson Monarch	not grown	—	—		
	Detroit	17.1	14	50		
	Detroit	not grown	20	—		
	Detroit	**24.4**	14	80		
	Detroit Dark Red (Ferry's strain) ...	no record	—	100	—	15
	Detroit Dark Red (Morse's strain) ...	**25.9**	—	28		
	Detroit No. 6	18.3	3	25		
	Detroit No. 26	**22.3**	0	19		
	Detroit Select Globe	**23.1**	20	50		

TABLE III—*continued*

Class C. 'Detroit Globe' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown		Late sown	
			1953	1954	1953	1954
	D.B. & T's Carrington Perfection ...	**22.0**	25	44		
	Dickson's Dark Red Globe	**21.0**	14	62		
	Dobies' Crimson Globe	**23.6**	—	50		
	Dunns Perfection Globe	**22.9**	9	65		
	Early Model	**21.8**	14	56		
	Early Red Globe Select	**22.3**	—	19		
	Early Round	**25.3**	—	53		
	Empire Globe	**23.0**	10	53		
	E.W.K.'s Blood Red Globe	**21.9**	7	59		
	E.W.K.'s Crimson Globe	20.1	7	28		
	Finney's Model Globe	**22.6**	10	22		
	Finney's Ruddigore	**21.0**	7	25		
	Fireball	**23.8**	14	22		
	Fogwills Crimson Beauty	**24.1**	14	22		
	Fogwills New Dark Red	16.0	—	44		
	Good for All	**24.5**	14	62		
	Harrisons' Early Wonder	not grown	20	—		
	Harrison's Summer Globe	**21.5**	7	25		
	Imperial Early Globe	**24.3**	14	28		
	Johnson's Perfect Globe	**21.0**	7	47		
	Kelway's Perfect Model Globe (Kelway)	**23.6**	—	65	NO	NO
	Kelway's Perfect Model Globe (Dickson)	20.0	14	47		
	Laxton's Crimson Ball...	18.8	12	44		
	Leightons Crimson Globe	**22.4**	25	75		
	Market Wonder Globe	17.6	20	59		
	Model Early Red Globe	**27.4**	10	47		
	Müller's Beste von Allen	**24.3**	10	44		
	Perfection Globe	**24.1**	—	28		
	Rouge-noir ronde hâtive	**21.3**	20	40		
	Round Red	**24.8**	—	44		
	Ruby Red	**23.1**	—	50		
	Ruddigore	19.9	14	59		
	Ryders' Crimson Ball	20.6	20	72		
	Speed's Early Perfection Globe ...	18.9	20	37		
	Sutton's Globe	19.8	0	37		
	The Cooper Taber	20.3	—	53		
	Toogood's Blood Royal Globe ...	**22.4**	20	65	BOLTING	BOLTING
	Toogood's Earliest of All Globe ...	**23.9**	7	53		
	Webbs' Crimson Epicure	20.4	7	47		
	Webbs' Reliance Globe	**21.3**	10	59		
	Woodwards Vulcan Reselected ...	**23.0**	10	65		
	Yates' Fireball	**24.5**	25	31		
	Yates' Benefactor	**21.6**	7	44		
C2	Crimson King	**22.5**	7	50		
	Daniels' Acquisition	not grown	—	—		
	Early Model Red Globe	not grown	5	--		
	Early Wonder	not grown	20	—		
	Fogwills Earliest of All	20.3	7	25		
	Harrisons' Special Short Top	**22.6**	33	47		
	L. & B.'s Model Red Globe	**24.8**	10	40		
	Ryders' July Globe	18.4	10	53		
C3	Arnold's Red Globe	20.1	14	40		
	Daniels' Model Globe	not grown	—	—		
	Feltham Globe	18.0	20	69		
C4a	Cannells' Ebony Globe	not grown	—	—		
	Green Top Early Wonder	**30.6**	—	59		
	Harrisons' Early Green Top	**22.9**	4	59		
	Red Ball	**27.6**	—	47		
	Woodheads Perfecta	**27.5**	20	62		
C4b	Beet, Early Crop	not grown	—	—		
C5	Sigma	**23.1**	0	15		
C6	Detroit No. 16	no record	50	100	7	25

TABLE III—*continued*

Class C. 'Detroit Globe' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting % Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
C7	Bees' Crimson Globe	**25.5**	20	31	NO BOLTING	NO BOLTING
	Bunting's New Blood Red Globe ...	20.6	10	56		
	Detroit	**27.8**	14	28		
	Elsoms Crimson Globe Select ...	19.9	14	47		
	Exhibition Globe	**27.0**	10	56		
	Pennells' Ruby Globe	**28.4**	25	44		
	Pennells' Selected Detroit	**28.3**	10	25		
	Rote Kugel	**24.9**	10	34		
	Sharpe's Extra Selected Crimson Globe	**24.3**	17	53		
	The King Globe	**23.1**	20	50		
	Tonkin's Deep Blood Red Globe ...	**24.0**	20	47		

Mean weight : s.e. for a difference between two means of varieties = ±2.57 lb.

Group	C3	C2	C1	C5	C7	C4
Mean root weight ...	19.0	21.7	22.1	23.1	24.9	27.1

TABLE IV

Class D. 'Intermediate' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting % Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
D1a	Arnold's Intermediate	**24.9**	0	28		
	Bees' Intermediate	**25.9**	4	25		
	Croll's Acquisition	not grown	—	—		
	Elsoms Early Intermediate	**25.6**	0	19		
	E.W.K.'s Intermediate	**25.9**	14	31		
	Feltham Intermediate	**28.4**	0	15		
	Finney's Selected Intermediate ...	**27.1**	0	12	NO BOLTING	NO BOLTING
	Fogwills New Intermediate	22.1	0	19		
	Hawlmark Intermediate	**26.4**	3	25		
	Kelway's Kitchener	**25.1**	3	25		
	L. & B.'s New Oval	**26.3**	0	31		
	Leightons Intermediate	**27.6**	4	28		
	New Intermediate	**25.3**	4	40		
	Nonpareil	22.3	4	15		
	Obelisk	not grown	0	—		
	Obelisk	**27.3**	0	19		
	Rocket	**26.3**	0	22		
	Ryders' New Oval	23.6	4	25		
	The Beesian Beet	**28.6**	0	19		
	Toogood's Sultan	**25.1**	0	15		
	Unwins Intermediate	22.0	0	15		
	Webbs' Intermediate	**24.3**	30	22		
	Woodwards Improved Nonpareil ...	**29.0**	4	25		
D1b	C.W.S. Intermediate	**24.6**	3	22		
	Daniels' Intermediate Red	not grown	—	—		
	New Intermediate	not recorded	4	—		
D2	Nonsuch	**26.1**	0	19		
	Obelisk	**27.4**	0	22		
	Obelisk	**29.4**	7	28		
D3	Clucas' Excelsior	**25.8**	0	15		
	Harrison's Perfectus	22.7	4	28		

Mean weight : s.e. for a difference between two means of varieties = ±2.49 lb.

Group	D3	D1	D2	Sub-group	D1b	D1a
Mean root weight ...	24.3	25.6	27.6	Mean root weight ...	24.6	25.7

TABLE V

Class E. 'Cheltenham Greentop' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
E1	Cheltenham Greentop Selected ...	**18.0**	NO BOLTING	NO BOLTING	NO BOLTING	NO BOLTING
	Cheltenham Greentop Selected ...	**17.0**				
	Cooling's Omega	**14.8**				
	Cundy's Extra Selected Cheltenham Greentop	**18.3**				
	E.W.K.'s Selected Cheltenham Green-leaved	**16.0**				
	Greentop Beet	**20.0**				
	Harrisons' Cheltenham Green-leaf ...	not grown				
	Harrison's Improved Cheltenham Greentop	**13.5**				
	King of the Market	**16.3**				
	Sutton's Greentop	**20.3**				
E2	Cheltenham Vigour	**14.5**				
E3	Long Red Green-leaved	**16.0**				
E4	Clibrans' Exhibition Black Long ...	19.3				
	Cobham Early	18.9				
	Cooks' Delight	not grown				

Mean weight : s.e. for a difference between two means of varieties = ±3.51 lb.

Group	E2	E3	E1	E4
Mean root weight ...	14.5	16.0	17.1	19.1 (cannot be compared with E1, E2 and E3).

Note. Varieties in Group E4 were included in the 'Intermediate' class trial, and so their yields cannot be compared with those of the other varieties and groups in Class E.

TABLE VI

Class F. 'Non-bleeding' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
F1	Arnold's Blood Red	13.0	NO BOLTING	NO BOLTING	NO BOLTING	NO BOLTING
	Bell's Deep Blood Red...	11.3				
	Best of All	16.8				
	Carters Blood Red	12.0				
	Clibrans' Non-bleeding Deep Blood Red	9.5				
	Croll's Exhibition Blood Red ...	14.0				
	Dobbie's Purple Beet	**21.5**				
	Dobbie's New Purple	11.3				
	Dobies' Purple	10.8				
	Finney's Exhibition Black	12.8				
	Fogwills Black	11.5				
	L. & B's Exhibition Black	13.8				
	Non-bleeding Deep Blood Red ...	15.5				
	Veitch's Superb Red	12.0				
	Webbs' Volunteer	14.3				

TABLE VI—*continued*

Class F. 'Non-bleeding' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
F2	Bell's Galloway Purple	**23.8**	NO BOLTING	NO BOLTING	NO BOLTING	NO BOLTING
	Bell's Non-bleeding	**25.0**				
	Dobbie's Purple	**21.0**				
	Goldie's Superb Black	19.5				
	Non-bleeding (Finney's)	**23.0**				
	Non-bleeding (Fogwills)	**21.3**				
	Non-bleeding Purple	**22.0**				
	Sutton's Black	**25.8**				
F3	Black Queen	**21.5**				
	Rouge Foncé de Massy	**28.0**				
F4	Lang rote	16.3	21	21		
	Lang sortrød forbedret	16.8	12	12		
	Long Dark Red (above ground) ...	17.0	12	12		
	Rouge-noir longue des vertus ...	17.8	9	9		

Mean weight : s.e. for a difference between two means of varieties = ±3.02 lb.

Group	F1	F4	F2	F3
Mean root weight ...	13.3	17.0	22.7	24.7

TABLE VII

Class G. 'Dwarf Black' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown 1953	Early sown 1954	Late sown 1953	Late sown 1954
G1a	Arnold's Black	**9.8**	NO BOLTING	NO BOLTING	NO BOLTING	NO BOLTING
	Dell's Crimson	**10.5**				
	Dicksons' Paragon	**10.0**				
	Dickson's Superb Dwarf-Top Black ...	7.3				
	Howcroft's Blood Red	**7.8**				
	Kelway's Choice Dwarf Dark ...	**10.3**				
	Sutton's Blood Red	**10.8**				
G1b	Carters Perfection	**15.3**				
	Pragnell's Exhibition	**14.5**				
G1c	Dicksons' Epicure	**14.5**				
	Fidler's Blood Red	**13.7**				
	Nutting's Dwarf Red	**18.8**				
G2	Non Plus Ultra	**12.0**				
I	Rouge Crapaudine	**12.3**				

Mean weight : s.e. for a difference between two means of varieties = ±2.24 lb.

Group	G1	G2	I
Mean root weight	12.0	12.0	12.3

Sub-group ...	G1a	G1b	G1c
Mean root weight	9.5	14.9	15.7

Note. Rouge Crapaudine (Class I) was included in this trial only for convenience.

TABLE VIII

Class H. 'Covent Garden' types

Group	Variety	Mean weight per 20 roots (lb.) 1954	Bolting %			
			Early sown		Late sown	
			1953	1954	1953	1954
H1	Pennells' Superb	**13.3**	0	0		
H2a	Cooper's Market King	**17.5**	0	3		
	Cundy's Select Dwarf Red	**16.8**	—	9		
	C.W.S. Blood Red	**14.3**	5	12		
	Ryders' Blood Red	**12.3**	3	0		
	Speed's Selected Covent Garden ...	**18.8**	3	0		
H2b	Barr's Covent Garden	**16.0**	3	6	N	N
	Covent Garden Red	**15.0**	0	3		
	Dell's Black-leaved	**14.3**	3	12	O	O
	E.W.K.'s Select Dark Red	**14.8**	3	3		
	Laxton's Exhibition	**15.5**	4	3		
	Middleton Park Favourite	**14.8**	3	9		
	Toogood's Blood Red Long	**15.0**	3	12	B	B
	Yates' Exhibition Blood Red	**15.8**	3	12		
H3a	Dewar's Northumberland	**15.8**	4	12	O	O
	Elsoms Select Long Red	**19.5**	3	0	L	L
	Exhibition Crimson Long	**15.0**	0	3		
	Finney's Northumberland	**16.0**	4	12	T	T
	Improved Long Dark Red	**11.5**	4	12		
	Nutting's Select Dwarf	**14.3**	0	3	I	I
	Reine des Noires	**13.0**	0	6	N	N
	Select Long Blood Red	**18.5**	3	0		
	Toogood's Crimson King	**12.5**	15	3	G	G
H3b	Exhibitor	**14.0**	—	3		
H3c	Arnold's Market Favourite	**14.3**	3	6		
H4a	Nutting's Select Red	**13.0**	5	15		
	Webbs' Improved Dark Red	**13.5**	3	9		
H4b	Harrison's Prize	**14.5**	3	0		

Mean weight : s.e. for a difference between two means of varieties = ±2.88 lb.

Group	H1	H4	H3	H2
Mean root weight ...	13.3	13.7	14.9	15.5

Sub-group	H2b	H2a	H3b	H3c	H3a	H4a	H4b
Mean root weight ...	15.2	15.9	14.0	14.3	15.1	13.3	14.5

DISCUSSION

266 varieties were studied and were placed into 40 distinct groups, although in some years, owing to environmental effects, the characters used to differentiate certain pairs of groups were ineffective. The number of varieties differed considerably in different groups, the biggest group of 75 varieties occurring within the 'Detroit' class, thus indicating its high degree of popularity. For reasons already given, varieties within any particular group are not regarded as synonyms but as 'near similars' which are probably closely related. British varieties in the trial numbered 210 and foreign varieties 56. 22 of the foreign varieties formed 14 groups and the remaining 34 varieties were distributed among half of the other 26 groups. On the whole, most of the foreign varieties were found to be in the Flat and Globe classes, 10 only being present in the Intermediate and Long classes, thus suggesting that varieties of the latter classes are unpopular, especially on the Continent of Europe.

In this country there seems to be a frequent renaming of varieties of red beet, especially within the 'Detroit' class. In addition, material grown from seed supplied by the same merchant, in different years, under the same name, may differ appreciably. This may or may not result from a need to propagate from two stocks in alternate years with this biennial seed crop. The naming of new types is obviously essential but in the public interest it is desirable that such new types should afterwards keep their

original names. Two years after a new and distinctive novelty had been marketed, it appeared under two new names. The seed of these two 'new' varieties had been obtained from the raiser.

The only serious disease was mildew which caused die-back of the apical growing point, and reduced the potential yield. Four groups only were susceptible, C6, E3, F1 and F2 and in each case the roots were of good colour and had no visible rings. Only three other groups, F3, F4 and G4 possessed these two highly desirable characters.

In yield performance, varieties within Classes B (Egyptian Globe) and E (Cheltenham Greentop) did not differ significantly, according to the Duncan test (6) and one variety only in Class H (Covent Garden) was significantly different from the highest yielder of that class. A large proportion of the varieties in each of the remaining classes did not differ significantly from the best yielder of their respective class. Mean yields of certain groups differed significantly. Within the 'Non-bleeding' (F) class, the varieties in group F1 gave a very low mean yield in 1954 owing to a heavy attack by mildew. Varieties in group F2, however, all of which were susceptible, recovered sufficiently from the disease to give yields comparable with group F3 varieties, which are resistant.

The Tables show that early sowing increased the percentage of plants having the annual habit, i.e. bolting. Varieties in Classes B (except group B2) and C (Detroit Globe) reacted most to this early sowing and had high percentages of bolters ; varieties in Class D (Intermediate) were less affected and those in Classes A (Flat Egyptian) and H were only slightly affected ; no bolting occurred in Classes E, F (except group F4), G (Dwarf Black) and I (Rouge Crapaudine).

In general, the percentage of bolters in the early sown susceptible varieties was greater in 1954 than in 1953, indicating that the cold weather during spring and early summer encouraged bolting.

Globe and flat varieties are grown for sale as early bunched beet, i.e. they are required to grow quickly to a marketable size, and varieties in the other classes do not meet with these requirements, with the exception of one variety, Cobham Early. Other desirable characters for early bunching are freedom from bolting when sown early, uniformity, good internal root colour and absence of rings, but not one of the varieties examined in the globe and flat classes possessed the combination of all these four characters. Detroit No. 16, a Canadian variety, was the only globe found to have a good colour and absence of rings, but unfortunately it was susceptible to mildew and was the most prone of all varieties to bolt. There are globe varieties, however, which are non-bolters and resistant to mildew although they have unsatisfactory colour and rings. There are also long varieties with all four desirable characters. Such globe and long varieties have been hybridised with Detroit No. 16 with the object of combining all desirable characters in a globe variety. With the same object, crosses have been made between the above varieties and flat varieties. In these and other respects, the information derived from this study has enabled a fairly precise breeding programme to be planned and put into operation, thus reducing the element of chance in bringing about the desired result.

SUMMARY

266 varieties of red beet have been grown at the N.V.R.S. and classified. Four categories were divided into eight classes and these were sub-divided into 40 groups, each group containing 'near similar' varieties. Lists are given of the varieties in each group and descriptions are given of the characteristics of the varieties in each group. Yield performances are given for one year only (1954) and bolting performances for two years. An indication is given of the value of the information obtained for the planning of a breeding programme.

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APPENDIX

INDEX OF GROUPING OF RED BEET VARIETIES

Variety	*Class (Initial) and Group (Numeral)*
Ægyptisk fladrund	A4
Aegyptische plattrunde	A2a
Aegyptische plattrunde dunkelrote	A2a
Aegyptische verbesserte dunkellaubige	A8
Arnold's Black	G1a
Arnold's Blood Red	F1
Arnold's Intermediate	D1a
Arnold's Market Favourite	H3c
Arnold's Red Globe	C3
Asgrow Wonder	A6
Barr's Early Red Globe	B1
Barr's Covent Garden	H2b
Bees' Crimson Globe	C7
Bees' Intermediate	D1a
Beet, Early Crop	C4b
Bell's Galloway Purple	F2
Bell's Deep Blood Red	F1
Bell's Non-bleeding	F2
Best of All, Sharpe's	F1
Black Queen	F3
Blood Red Globe	C1
Bunting's New Blood Red Globe	C7
Cannells' Blood Red Globe	C1
Cannells' Ebony Globe	C4a
Cannells' Little Nigger	C1
Carters Blood Red	F1
Carters Crimson Ball	C1
Carters Perfection	G1b
Cheltenham Greentop Selected	E1
Cheltenham Vigour	E2
Claudia	B4b
Clibrans' Black Knight Globe	C1
Clibrans' Exhibition Black Long	E4
Clibrans' Non-bleeding Deep Blood Red	F1
Clibrans' Selected Red Globe	C1
Clucas' Excelsior	D3
Cluseed Empire Globe	C1
Cooks' Delight	E4
Cooling's Omega	E1
Covent Garden Red	H2b
Cooper's Market King	H2a
Cooper's Market Wonder Globe	C1
Cobham Early	E4
Crimson Gem	C1
Crimson Globe	C1
Crimson Globe Select	C1
Crimson Globe Selected	B1
Crimson King	C1, C2
Crimson King Globe	C1
Croll's Crimson Ball	C1
Croll's Acquisition	D1a
Croll's Exhibition Blood Red	F1
Crosby's	A5, A6
Crosby's Egyptian	A5
Cundy's Extra Selected Cheltenham Greentop	E1
Cundy's Perfect Globe	C1
Cundy's Select Dwarf Red	H2a
Cundy's Selected Early Model Crimson Globe	C1
C.W.S. King of the Globe	C1
C.W.S. Intermediate	D1b
C.W.S. Selected Crimson Globe	C1
C. W. S. Blood Red	H2a
Daniels' Acquisition	C2
Daniels' Crimson Monarch	C1a
Daniels' Intermediate Red	D1b
Daniels' Model Globe	C3
Dell's Black-leaved	H2b
Dell's Crimson	G1a
Deep Blood Red Globe	B1
Detroit	C7, C1
Detroit Dark Red	C1
Detroit No. 6	C1
Detroit No. 16	C6
Detroit No. 26	C1
Detroit Select Globe	C1
Dewar's Northumberland	H3a
D. B. & T.'s Carrington Perfection	C1
Dickson's Dark Red Globe	C1
Dicksons' Epicure	G1c
Dicksons' Paragon	G1a
Dickson's Superb Dwarf Top Black	G1a
Dobbie's Purple	F2
Dobbie's Purple Beet	F1
Dobbie's New Purple	F1
Dobbie's Selected Globe	B1
Dobies' Crimson Globe	C1
Dobies' Purple	F1
Dunns Perfection Globe	C1
Early Blood Turnip	A7
Early Flat Egyptian	A2b
Early Model	C1
Early Model Red Globe	C2
Early Red Globe Select	C1
Early Round	C1
Early Wonder	C2
Eclipse	B5
Egyptian Extra Early	A1, A2a, A2b
Egyptian Improved	A3
Egyptian Turnip-rooted	A2a, A2b, A4
Egyptisk plattrund	A2b
Elsoms Crimson Globe Select	C7
Elsoms Early Intermediate	D1a
Elsoms Select Long Red	H3a
Empire Globe	C1
E.W.K.'s Blood Red Globe	C1
E.W.K.'s Crimson Globe	C1
E.W.K.'s Intermediate	D1a
E.W.K.'s Select Dark Red	H2b
E.W.K.'s Selected Cheltenham Green-leaved	E1
Exhibition Crimson Long	H3a
Exhibition Globe	C7
Exhibitor	H3b
Feltham Globe	C3
Feltham Intermediate	D1a
Feuerkugel	B3
Fidler's Blood Red	G1c
Fidler's Model Globe	B3
Finney's Exhibition Black	F1
Finney's Model Globe	C1
Finney's Northumberland	H3a
Finney's Ruddigore	C1
Finney's Selected Intermediate	D1a
Fireball	C1
Fire Ball	B6
Flat Egyptian	A2a, A2b
Fogwills Black	F1

APPENDIX—*continued*

INDEX OF GROUPING OF RED BEET VARIETIES

Variety	*Class (Initial) and Group (Numeral)*
Fogwills Crimson Beauty	C1
Fogwills Earliest of All	C2
Fogwills New Dark Red Globe	C1
Fogwills New Intermediate	D1a
Frühe Wunder	A7
Good for All	C1
Goldie's Superb Black	F2
Greentop Beet	E1
Green Top Bunching	B2
Green Top Bunching (Morse)	B2
Green Top Early Wonder	C4a
Harrisons' Cheltenham Green-leaf	E1
Harrisons' Early Wonder	C1
Harrisons' Early Green Top	C4a
Harrisons' Special Short Top	C2
Harrison's Perfectus	D3
Harrison's Prize	H4b
Harrison's Summer Globe	C1
Harrison's Improved Cheltenham Greentop	E1
Hawlmark Intermediate	D1a
Howcroft's Blood Red	G1a
Imperial Early Globe	C1
Improved Long Dark Red	H3a
Johnson's Perfect Globe	C1
Kelway's Choice Dwarf Dark or Crimson Gem	G1a
Kelway's Kitchener Intermediate	D1a
Kelway's Perfect Model Globe	C1
King of the Market	E1
Lang rote	F4
Lang sortrød forbedret	F4
Laxton's Crimson Ball	C1
Laxton's Exhibition	H2b
L. & B.'s Exhibition Black	F1
L. & B.'s Model Red Globe	C2
L. & B.'s New Oval	D1a
Leightons Crimson Globe	C1
Leightons Intermediate	D1a
Long Dark Blood (above ground)	F4
Long Red Green-leaved	E3
Market Wonder Globe	C1
Middleton Park Favourite	H2b
Model Early Red Globe	C1
Müller's Beste von Allen	C1
New Intermediate	D1a, D1b
Non-bleeding	F2
Non-bleeding Deep Blood Red	F1
Non-bleeding Purple	F2
Nonpareil	D1a
Non Plus Ultra	G2
Nonsuch	D2
Nutting's Dwarf Red	G1c
Nutting's Select Dwarf	H3a
Nutting's Select Red	H4a
Obelisk	D1a, D2
Pragnell's Exhibition	G1b
Pennells' Selected Detroit	C7
Pennells' Superb	H1
Pennells' Ruby Globe	C7
Perfected Detroit	B3
Perfection Globe	C1
Red Ball	C4a
Reine des Noires	H3a
Rocket	D1a
Rocket Intermediate	D1a
Rote Kugel	C7
Rote Rüben Aegyptische	A2b
Rouge Crapaudine	I
Rouge Foncé de Massy	F3
Rouge-noir longue des vertus	F4
Rouge noir plate d'Egypte améliorée	A1
Rouge-noir ronde hâtive	C1
Round Red	C1
Ruby Red	C1
Ruddigore	C1
Runde, sortrød, mørkløvet	B7
Runde schwarzrote dunkellaubige	B7
Ryders' Blood Red	H2a
Ryders' Crimson Ball	C1
Ryders' July Globe	C2
Ryders' New Oval	D1a
Select Long Blood Red	H3a
Sigma	C5
Spangsbjerg	B1, B4b
Speed's Early Perfection Globe	C1
Speed's Selected Covent Garden	H2a
Sutton's Black	F2
Sutton's Blood Red	G1a
Sutton's Globe	C1
Sutton's Greentop	E1
Sharpe's Extra Selected Crimson Globe	C7
Tall Top Early Wonder	B4a
The Beesian Beet	D1a
The Cooper Taber	C1
The King Globe	C7
Tonkin's Deep Blood Red Globe	C7
Toogood's Blood Red Long	H2b
Toogood's Blood Royal Globe	C1
Toogood's Crimson King	H3a
Toogood's Earliest of All Globe	C1
Toogood's Sultan	D1a
Unwins Intermediate	D1a
Veitch's Superb Red	F1
Webbs' Crimson Epicure	C1
Webbs' Improved Dark Red	H4a
Webbs' Intermediate	D1a
Webbs' Reliance Globe	C1
Webbs' Volunteer	F1
Woodheads Perfecta	C4a
Woodwards Improved Nonpareil	D1a
Woodwards Vulcan Reselected	C1
Yates' Benefactor	C1
Yates' Fireball	C1
Yates' Exhibition Blood Red	H2b

CHEMISTRY REPORT

By F. HAWORTH

FIELD EXPERIMENTS

The three long-term experiments laid down in 1953 (1) have been continued and the patterns of crop response to the cultural and manurial treatments are now being shown. It appears from the results of the first cycle of three years' cropping that weather conditions, especially rainfall, have determined to a large extent the yield of a crop and that whilst manurial responses have been considerable in any one year, they have been smaller than the annual fluctuations in yield caused by the weather.

Cultivation experiment

In the first year (1954) of this experiment, the deep ploughing and the shallow ploughing with subsoiling treatments benefited Brussels sprouts, peas and spring cabbage but the yield of leeks was increased by the shallow ploughing and the rotavating treatments. In the following year (1955) Brussels sprouts and leeks showed considerable responses to the deep ploughing and to the shallow ploughing with subsoiling treatments, whereas peas did not respond differentially to the different primary cultivation treatments. The spring cabbage crop (1955-56) was very poor owing to frost damage and the different cultivation treatments did not appear to affect the extent of frost injury or the recovery from damage.

The effects of the cultivation treatments in 1956 on the yields of Brussels sprouts, peas and leeks were similar to those shown in 1955.

In April 1956, it was seen that the growth of peas on plots which had had shallow rotavation (6 inches) as their primary cultivation for two-and-a-half years was markedly poorer than the growth of peas on plots which had received shallow or deep ploughing treatments. An investigation showed that downward root penetration was impeded on the rotavated plots by a hard pan at a depth of six inches for a period of about ten days. During this time the peas grew slowly and at 39 days from sowing they were about one half the size and weight of the plants grown on the ploughed plots. This large difference in plant size was maintained until the peas were picked in July.

At harvest, however, there were no significant differences in yield of green pods from the different treatments of cultivation and manuring. The total amount of growth on the rotavated plots was about two thirds of that on the ploughed plots but the pod: haulm ratio was higher and hence the yield of pods was the same from all cultivation treatments. It appeared that the different treatments produced no differences in date of maturity of the pea crop.

Nitrogen experiment

There has been little change in the pattern of crop responses in this experiment from that described in the Annual Report for 1955.

In an attempt to assess the effect of the treatments on earliness in the early potato crop, each plot of the experiment was divided into four parts. One part of each plot was harvested at separate harvests at seven day intervals. Each harvest was completed as quickly as possible and within one working day. The results showed that there was a slight tendency for the higher nitrogen treatments to delay tuber formation but the effect was not significant. At the fourth and last harvest, the higher nitrogen levels gave a slightly higher yield of tubers but again the effect was not significant.

An interesting observation was that at the time of harvest the weight of tubers was increasing at the rate of 3 cwt. per acre per day. This rapid rate of growth should be taken into account when harvesting experiments on early potatoes, especially where yields are the main interest.

NPK-FYM factorial experiment

The main responses of the crops so far have been to FYM. The percentage increase in yield attributable to FYM varied with the crop, being about 80 per cent for red beet, 60 per cent for carrots and 40 per cent for early potatoes and spring cabbage. Smaller responses have been obtained from the nitrogen and potash treatments. The effect of potash and FYM have, in general, shown a significant interaction ; the responses to potash applications having been less in the presence of FYM than in its absence. Only early potatoes grown in 1955 have shown any appreciable response (17 per cent) to phosphate manures either in presence or absence of FYM. This lack of response to phosphatic applications was surprising, for soil analysis using standard extraction methods had shown that the phosphate status of the soil was quite low.

It would seem that for any one crop the percentage increase in yield caused by FYM was of the same order in different years but that the general yield level of the crop was largely determined by climatic conditions (Table I).

TABLE I

Yield of early potatoes and red beet in tons per acre and percentage increase caused by FYM applications

		Early potatoes		Red beet	
		yield	% increase	yield	% increase
1954	FYM	10.45	42	8.12	64
	None	7.41		4.96	
1955	FYM	4.66	36	8.49	111
	None	3.42		4.02	
1956	FYM	5.76	54	16.00	83
	None	4.19		8.71	

Leaf material taken from the 1955 early potato and red beet crops was analysed for its inorganic constituents. Further leaf samples were taken during 1956 for subsequent analysis. In addition, plant material of red beet has been used for biochemical studies.

Two further field experiments on nutrition were carried out during the year. Self-blanching celery grown at Wellesbourne so far has suffered from an internal stem breakdown especially of the older leaves. This condition can lead to substantial losses mainly by reducing the size of the marketable head. Similar conditions have been described by many workers and attributed in the main to a deficiency of boron. Whilst boron applications of up to 60 lb./acre have had some beneficial effect in this experiment, it would appear that the calcium and potassium supply were also of importance, and that the condition may have been caused by nutrient unbalance rather than by actual boron deficiency. Further work will be done on this problem, including detailed leaf analysis of the experimental crops.

The second experiment concerned the manuring of runner beans. During 1955 and 1956 crops of runner beans on a site near Banbury and on the nutrition reference plots at the E.H.S. Luddington showed poor response to inorganic fertilisers. Plots at Luddington which had received small dressings of FYM grew much better crops of runner beans than those which had received only inorganic fertilisers. At Wellesbourne, where the experiment was irrigated as required, FYM more than doubled the yield of runner beans as compared with a mixed or compound fertiliser. No root nodules

could be found on any of the plants examined, but around (not in) lumps of FYM buried at different depths in the soil there were more small roots than in the general body of the soil. This experiment will be repeated in 1957.

ORGANIC CONSTITUENTS OF RED BEET (S. P. Spragg)

A study was made of the sugars and nitrogenous constituents of samples of leaves and roots of red beet plants taken during 1955 and 1956 from some of the plots of the NPK-FYM factorial experiment. Samples, consisting of whole plants, were taken at frequent intervals throughout the growing season from plots receiving the following manurial treatments : $D_0\ N_1\ P_0\ K_0$, $D_0\ N_1\ P_0\ K_2$, $D_0\ N_3\ P_0\ K_0$ and $D_0\ N_3\ P_0\ K_2$ (1). The roots and leaves from each sample were analysed separately for total nitrogen, individual amino acids, individual sugars and higher molecular weight nitrogenous fractions, e.g. proteins.

Measurements of the whole plant samples showed that the plants from plots receiving the higher levels of nitrogen (N_3) and/or potash (K_2) were larger than those from plots receiving the lower levels of the two fertilisers. Comparison of the results of measurements on the samples used in this study with the yield measured at harvest on a whole plot basis, showed that the samples used were representative of the whole plot.

The percentage dry weight of the roots and of the leaves was not affected by manurial treatments in 1955 or in 1956. The analytical results for the samples taken during these two years showed that for both leaves and roots, differences in chemical composition attributable to manurial treatments were smaller than the differences attributable to the different growing conditions during the years 1955 and 1956. In general, however, the sucrose content of the roots was increased at the higher levels of potash manuring (K_2) and was not affected by the level of nitrogen fertiliser.

The picture of the nitrogenous components of the leaves and of the roots of red beet as affected by manuring is far from clear. For instance, in 1955 both leaves and roots of plants from plots receiving high levels of nitrogen (N_3) contained less total protein (as a percentage of the dry weight) than the leaves and roots of plants from the low nitrogen (N_1) plots, whereas the reverse held in corresponding samples taken from the same plots in 1956. The study was extended during 1956 to deal with the chemical changes taking place in the various parts of the plant during the bolting of red beet. Plants seeding in their second year of growth, and early sown plants seeding in their first year of growth have been analysed.

VIRUS INHIBITORS (S. P. Spragg)

Work was continued on the chemical characterisation of the compounds present in expressed rhubarb sap which appear to inhibit the transmission of infections of tobacco mosaic virus. The substances responsible are similar to the tannins. A full report of this work will be published elsewhere.

Further studies were carried out on the virus inhibitor complex of watercress and some progress has been made towards reaching an understanding of the factors involved.

During 1956, a high voltage electrophoresis apparatus was constructed. The machine can be used up to 8,000 volts and 100 milliamps. Preliminary studies were made to determine the experimental conditions under which it may be used for the separation of large molecules.

The following analyses were carried out for other sections on the Station :— carotene in carrots for the Plant Breeding Section, zinc in watercress and in water for the Pathology Section, nitrogen in turnips for the Irrigation Section, and nitrogen, potassium, phosphorus and calcium in various plant materials for the Weed Ecology Section.

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IRRIGATION REPORT

By E. J. WINTER

Workers in the Irrigation Section have continued to investigate the effects of different watering treatments on growth, yield and quality of various crops. Special attention was paid to determining the stages of growth at which the plants were most sensitive to drought or wet periods.

Further work has been done on methods of assessing current soil moisture status and a number of special instruments were designed for this purpose and installed on the weather station (see page 71).

A series of long-term experiments has been started on the N.A.A.S. Experimental Horticulture Stations with the object of testing on a field scale the principles established on small plots at Wellesbourne.

IRRIGATION OF CAULIFLOWERS (P. J. Salter)

Results obtained previously showed no difference in growth rate or yield of Finney's 110 early summer cauliflower when the plants were allowed to use 25 per cent, 50 per cent or 75 per cent of the available soil water before irrigation was applied. In another experiment the growth rate and yield of Sutton's Novo autumn cauliflower was significantly reduced by imposing a treatment involving a greater soil moisture stress than any of those in the first experiment (1).

In 1956, pot-grown plants of variety Finney's 110 were planted out on 27th March. The soil moisture content was then brought to field capacity and the following watering treatments were begun :—

Treatment A The soil was restored to field capacity every day by adding an amount of water equal to that evaporated and transpired the previous day.

Treatment B Sufficient water was added to restore the soil to field capacity whenever the available water in the root zone had been depleted by 50 per cent.

Treatment C Sufficient water was added to restore the soil to field capacity whenever the whole of the available water in the root zone had been removed, i.e. the soil was allowed to dry to the theoretical wilting point.

These treatments covered a wider range than those used in the 1955 experiment on Finney's 110. All the plots were protected from rain by means of mobile glass shelters.

Weekly measurements of mean leaf area showed that the growth rate of the plants was considerably reduced before half of the available soil water had been used. The same person judged when each curd was ready for cutting. The yield of untrimmed and trimmed produce, and total leaf area were all significantly higher under the wet treatment (*A*) than under the drier ones. The date when 50 per cent of the curds had been cut was three to four days later under the wet treatment than under the others. On grading, it was found that the wet treatment had significantly increased the number of large curds.

Under the drier treatments the leaves became strap-shaped in contrast to the large, broad leaves produced under the wet treatment, while the wet conditions resulted in plants with a higher proportion of foliage than the drier treatments.

IRRIGATION OF CARROTS (G. Stanhill)

Carrot seed (variety Early Market) was sown in June and the crop was harvested in November. Throughout this period the following watering treatments were applied :—

Treatment A The soil was restored to field capacity every day by adding an amount of water equal to that evaporated and transpired during the previous day.

Treatment B Immediately after sowing, the soil moisture content was brought to field capacity. Subsequently sufficient water was added to restore the soil to field capacity whenever the whole of the available water had been lost from the root zone. In fact the soil under this treatment never reached permanent wilting point and so no water was applied after the initial application.

Mobile glass shelters were used to prevent rain from interfering with the treatments.

The wet treatment (*A*) resulted in a greater weight of edible roots and of foliage and a greater percentage of split and fanged roots as compared with the dry treatment (*B*).

Triangular tasting tests showed that roots grown under the dry treatment (*B*) were significantly sweeter, and had a stronger 'carrot' flavour, deeper colour and smoother texture than those grown under the wet treatment (*A*).

In another experiment with carrots the effects of the same two watering treatments were compared when they were applied for a two-week period only at fourteen different stages of development of the plants. Each plot was harvested sixteen weeks after sowing. During the period of treatment, the plots were sheltered from rain, but at all other times they were unprotected from rain and were given sufficient irrigation to ensure that the soil moisture content remained at a high level.

The mean difference between the effect of the two treatments on yield of edible roots was less than one per cent, and there was no interaction between age of plant at time of treatment and effect of the treatment on yield. The mean fresh weight of leaves at harvest was increased by the wet treatments by 8 per cent as compared with the dry treatments. However, when the wet treatment was applied at any time up to seven weeks after sowing, the weight of foliage was reduced by 7 per cent at harvest, while application of the wet treatment any time after the seventh week increased the weight of foliage by 24 per cent.

When the treatments were imposed between the eighth and thirteenth weeks after sowing there was no effect on number of split or fanged roots. On the other hand, plots given the dry treatment before or after this time yielded three times the number of split or fanged roots at harvest as compared with those given the wet treatment at comparable ages.

Triangular tasting tests showed that the effects caused by these treatments applied for only two weeks in the life of the plants, were similar to those obtained when the treatments were applied throughout the life of the crop, but, as might be expected, were smaller in magnitude. Nevertheless, significant differences were still detectable when a fortnight's differential watering had been applied twelve weeks before harvest.

IRRIGATION OF SUMMER LETTUCE (P. J. Salter)

Previous work on the irrigation of summer lettuce indicated that heavy watering in the seedling stage appeared to reduce ultimate yield (3), the highest yields being obtained when plants were not watered after the beginning of hearting (4).

Seed (variety Feltham King) was drilled in the field on 18th July 1956 and germination took place by 23rd July. The soil was then brought to field capacity, and differential irrigation treatments were begun. For this purpose, the expected time between planting and harvest was divided into five periods of a fortnight each. Two series of treatments were applied. In series A all plots began at field capacity, then no water was applied for an initial period after which the soil was restored to field

capacity and maintained in that state by daily irrigation until the crop was harvested. Four initial periods of 2, 4, 6 and 8 weeks were used, together with a fifth treatment in which no water was applied throughout the growth of the crop. In series B all plots began at field capacity and were maintained in that state by daily watering for an initial period, after which no water was applied until harvest. Five initial periods of 2, 4, 6, 8 and 10 weeks were used in this series. At each irrigation in both series sufficient water was applied to restore to field capacity only that depth of soil which the roots had penetrated. The amount of water was calculated by the Penman method. Mobile shelters were used to prevent rain from interfering with the treatments.

Results from series A showed that the five different treatments produced no significant differences in the number of plants established, in the yield of lettuce or in the percentage of marketable lettuce.

In series B, however, plants kept continuously at field capacity from planting to harvesting produced the largest marketable heads and discontinuing irrigation earlier during the growth of the plants resulted in smaller heads being produced. The smallest percentage of unmarketable produce came from plots maintained at field capacity from planting time to harvesting. As irrigation was stopped progressively earlier, so the percentage of unmarketable produce progressively increased. All these linear trends in the results from the series B treatments were statistically significant.

Thus continuously moist soil conditions from planting time until harvesting may be expected to increase the marketable weight per plant and reduce the amount of waste produce per plot. There appeared to be no period during which the growth of the lettuce plant was particularly sensitive to the different soil moisture conditions, although the results suggest that if irrigation is begun in the early stages of plant growth it should be continued until harvest, otherwise yields will be reduced.

In view of differences between some of the results obtained in this experiment and those of Winter (*loc. cit.*) and Hudson *et al.* (5), further work will be necessary to establish the moisture requirements of the lettuce crop for optimum growth and yield.

IRRIGATION OF A ROTATION OF CROPS

(E. J. Winter, P. J. Salter and G. Stanhill)

In co-operation with the E.H.S. staffs, experiments were started at Luddington, Stockbridge House and Rosewarne to determine the effect of different watering treatments on the various crops in a rotation grown in the open on a field scale (Table I). One replication of the Stockbridge House experiment was located at Wellesbourne to provide a pilot block for the three experiments.

TABLE I

Proposed crop rotations at the different centres

	Luddington	Rosewarne	Stockbridge House and Wellesbourne
1st year	early summer cauliflower summer lettuce	early potatoes Italian ryegrass	early summer cauliflower summer lettuce
2nd year	carrots self-blanching celery	anemones anemones	spring lettuce leeks
3rd year	spring lettuce leeks	anemones winter cauliflower	self-blanching celery
4th year	as 1st year	Italian ryegrass daffodils (for 2 years)	as 1st year

The layouts are arranged so that at each place all phases of the rotation are represented each year.

Immediately after sowing or planting each crop, the soil was restored, by watering, to field capacity. Differential watering was then begun. During 1956, the following three treatments were to be applied at all Stations, but rainfall was such that the conditions for watering plots under treatment *C* never arose, and in fact these plots were treated in the same way as the controls (treatment *A*).

Treatment A After raising the soil initially to field capacity no watering was given other than rainfall.

Treatment B Whenever the accumulated soil moisture deficit amounted to half an inch, the soil was restored to field capacity by irrigation.

Treatment C The soil was restored to field capacity, by irrigation, whenever half of the available water in the crop root zone had been used. The amount of available water at various depths down to 30 inches was determined by preliminary measurements of field capacity, wilting point and soil density. The depth reached by the crop roots was measured regularly, and when the accumulated soil moisture deficit amounted to half the available water in that depth of soil, irrigation was carried out.

The soil moisture deficit was calculated daily from meteorological observations according to Stanhill's extension of Penman's method.

Each crop was harvested and graded according to commercial practice, and the detailed results will be published elsewhere. In general, they support previous observations that the effect of irrigation is to increase the amount of foliage produced and is not necessarily accompanied by a corresponding increase in marketable produce. Where the foliage itself forms a considerable part of the marketable product, there is of course an increase in marketable yield. The most valuable increase resulting from irrigation was obtained with early summer cauliflowers at Luddington.

The authors wish to thank all those members of the E.H.S. staffs who have carried out the large number of measurements and calculations and compiled the detailed returns necessarily involved in these experiments.

EXPERIMENTS ON METHOD OF WATER APPLICATION (E. J. Winter)

In most of our experiments so far no attempt has been made to determine the effects of different methods and speeds (i.e. time taken to apply a given volume of water) of application of water. Bean and Wells (6) have examined the effects of variation in drop size on surface tilth of the soil, but few experiments have been described dealing with the effect of capping or temporary flooding on the growth of crops.

It has been reported previously (7) that the use of furrows or sprinklers to apply a given quantity of water to peas did not affect the yield except when heavy furrow applications were made during the seedling stage. Cultural difficulties were encountered in attempts to use furrow irrigation on lettuce. In 1955, the effect of sprinkle irrigation was compared with that of furrow irrigation on runner beans, applying the same quantity of water by each method. The beans were grown in rows, and the tops were pinched out as in commercial practice. The treatments were replicated twice only, but the yield of beans from the furrow-irrigated plots was consistently higher throughout the season than that from the sprinkled plots. In 1956, similar treatments were applied in an experiment with six replications and the first three pickings yielded significantly more beans from the furrow-irrigated plots than from the sprinkled ones. After the second picking, the weather deteriorated and remained so wet for the rest of the season that no further irrigation was possible. These results do not support the commonly-held view that sprinkling helps the set of runner bean flowers and so improves subsequent yield. It is possible that owing to losses of water by evaporation from the leaves and wet soil, the actual amount of water which reached the roots of the plants was less in the case of the sprinkled plots than the furrowed plots, and that this was

the cause of the difference in yield. However, no evidence in support of this theory was afforded by the results of soil moisture determinations. Stanhill (unpub.) has found that under some circumstances wetted leaves may transpire more than comparatively dry ones, and this may have aggravated the effect of any small local differences in soil moisture stress under the two treatments.

In three glasshouse experiments with forcing radish sown at various times during the winter, the same amount of water was applied to each plot at rates varying from a quarter inch per hour to one inch per hour. No difference between plots was observed as regards germination percentage, or yield of tops and edible roots. In a similar experiment on carrots there were indications that high rates of application of water reduced the weight of foliage and roots, and the number of plants which reached maturity. These trends, however, were statistically insignificant.

Other experiments are in progress with the object of elucidating the effect of different methods and rates of water application on establishment, growth and yield of vegetable crops.

FURTHER STUDIES ON THE LOSS OF WATER FROM PLANT/SOIL SYSTEMS (G. Stanhill)

Accurate estimations of evapo-transpiration by meteorological methods depend on plant and soil factors not being limiting to soil moisture loss. However, in commercial horticultural practice this condition may frequently not be fulfilled, and the effect of some plant and soil factors on soil moisture loss was studied during 1956.

1. *Plant factors.* Under the same evaporation conditions, water loss from a dry bare soil surface is only a small fraction of that from soil completely covered by transpiring vegetation (8). Measurements of the percentage of ground cover under an intensive market garden rotation (Table I, p. 48) were made at three centres. Between April and September, inclusive, the mean ground cover was only 21 per cent. The mean percentage cover during the life of a given crop was similar at the three centres but varied for different crops from 7 per cent to 41 per cent.

The effect of increasing plant cover on soil moisture loss has been investigated by following the changes in the ratio of actual to potential evapo-transpiration as the ground cover developed. Potential water loss was measured using a constant feed evaporimeter, the loss from which was found to be linearly related to the water loss from a crop completely covering the ground. Measurements on a carrot crop growing in moist soil have shown that the rate of loss increased linearly until 55 per cent cover had been achieved. After this stage the rate of loss increased very little so that the water loss from a crop of carrots covering 65 per cent of the ground was the same as that from a crop completely covering the ground. With a beetroot crop there was no difference in the rate of loss from crops covering 74 per cent and 100 per cent of the ground.

2. *Soil factors.* The effect of changes in soil moisture deficit on evapo-transpiration rate has been studied using the grass-covered weighable monolith lysimeters installed at the weather station (p. 71). These receive natural rainfall only and the effect of seasonal changes in soil moisture deficit on evapo-transpiration rate is shown in Fig. 1. The results indicated that there was a marked reduction in the rate of evapo-transpiration when over 70 per cent of the available water had been lost (corresponding to a deficit of three inches in the lysimeters). Neglect of this factor when using Penman's formula led to an over-estimate of water loss between April and September of 3.60 inches.

The effect of increase in the soil moisture deficit on rate of water loss from various crop plants has also been studied in the glasshouse. The water loss from plants watered at a half-inch soil moisture deficit was compared daily with that from plants which were not watered after planting in soil at field capacity. The plants were grown in John Innes compost in weighable metal cylinders sunk among a population of similar plants occupying an area of 100 square feet. The evapo-transpiration rate from grass was found to be reduced when more than 40 per cent of the available water

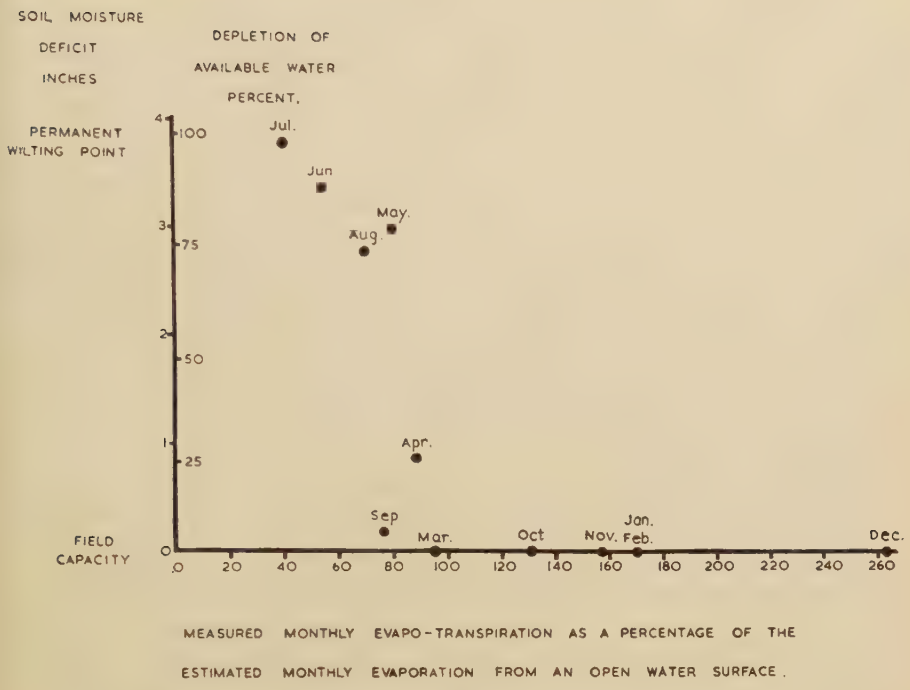

Fig. 1. Effect of soil moisture deficit on evapo-transpiration rate.

had been exhausted. With turnips and beetroot, the rate of evapo-transpiration was not reduced until 60 and 80 per cent, respectively, of the available water had been used.

The grass used in the glasshouse experiments was of the same strain as that planted in the lysimeters, and the difference in evapo-transpiration response in the two locations was therefore not caused by specific differences between the plants. The difference between the response of the beet, turnip and grass in the glasshouse may therefore also be due to temporary variations in local environment, and not necessarily to specific differences between these crops. Experiments to test this point are in progress.

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ENTOMOLOGY REPORT

By D. W. WRIGHT

Several lines of investigation, begun in 1955 were continued and expanded during 1956. These included studies on the biology and control of the lettuce root aphid, field and laboratory experiments on the control of carrot fly on parsnips and population studies on the cabbage root fly and certain of its predators. Work on the latter project was interrupted by a change in staff and is now being continued by Dr. R. D. Hughes. Research was also continued on problems connected with the control of cabbage root fly, cabbage stem weevil and pea moth. Further experiments were carried out to determine the effectiveness and mode of action of certain insecticides used for the control of carrot fly on carrots and to assess the effect of these chemicals on crop flavour.

CABBAGE ROOT FLY (D. W. Wright, R. Howells, Dorothy D. Bowe and J. S. Buxton)

Field experiments were carried out on early summer and autumn cauliflowers to assess the effect of cabbage root fly attack on crop yield and quality. There was a marked difference in yield between insecticide-treated and untreated plots on the autumn cauliflowers but, because of the cool wet conditions in early summer, comparatively little improvement resulted from treatment of the early summer cauliflowers. When the root systems were graded for damage, however, important differences in performance between various treatments were established.

Egg counts were made throughout the season on summer cabbage. Unusually small numbers were laid by the first generation of the fly in May and early June. The maximum rate of egg laying for the season was reached in early July. In 1954 and 1955, however, this occurred in May. From then, until mid-October, when laying ceased, the numbers laid declined rapidly. Egg counts were also made on summer cabbage plants growing on aldrin-treated soil and on plants of similar age growing on untreated soil. For a period of eleven weeks much larger numbers of eggs were found on the treated plots, a difference which may have been due to the larger size of the plants on those plots which were not being damaged by root fly.

Work on soil populations of the cabbage root fly and on its predators was continued. Field experiments gave results different from those obtained in 1955, probably because the weather was much cooler and wetter. Very few predators occurred on the experimental plots and the insecticide used (aldrin) was apparently more effective than in 1955. No further cases of increased cabbage root fly infestation, resulting from predator mortality, were recorded. On the evidence obtained over the past two years, the interaction between insecticides and predators in their effect on the population of cabbage root fly appears to vary from season to season, being affected by particular conditions of crop and climate.

CARROT FLY ON CARROTS (D. W. Wright)

Experiments to compare the effectiveness of aldrin, dieldrin and lindane for the control of carrot fly on carrots on fen soil at Chatteris, and on medium sandy loam at Wellesbourne, were continued. The insecticides were broadcast and rotavated into the top four inches of soil before sowing. At Chatteris each insecticide was applied at rates of 2 lb. and 4 lb. per acre. Part of each plot was sown with carrots immediately after treatment, at the end of March, and the remainder sown in June. The early-sown carrots on the untreated plots were severely attacked by the first generation of the fly and only a few plants survived. In contrast, on the dieldrin and lindane treated plots and those treated with the higher dosage rate of aldrin, crop growth was vigorous

throughout the season. Carrot samples taken at the end of July showed that protection against the carrot fly had been almost complete, less than 5 per cent of roots on any plot showing damage. On the 2 lb. per acre aldrin plots protection was less complete, the average infestation being 34.5 per cent with some roots very severely damaged.

All plots were re-sampled at the end of October, having then been exposed to the attack of the second generation of flies. The 2 lb. per acre aldrin plots showed a further increase in crop damage but on all the remaining insecticidal treatments there were no significant increases in attack compared with July. The few surviving carrots on the control plots were stunted, pest ridden and valueless.

Samples were taken from the June sown carrots in late October and showed that the various treatments had, in each case, given a control of carrot fly comparable with that achieved on the early-sown carrots against the first generation. The damage on the control plots was severe, but, with the exception of the 2 lb. per acre aldrin treatment the carrots on all the remaining treatments were free or almost free of damage.

A similar experiment with early and late sown carrots was carried out at Wellesbourne. The treatments involving 4 lb. per acre rates of dieldrin and lindane were, however, omitted and a 1 lb. per acre rate substituted in each case. There was little attack by the first generation on any plots but in November the infestation on the control plots averaged 57.5 per cent and 20 per cent for the early sown and June sown carrots respectively. Samples taken in November from the insecticide treated plots showed a complete absence of damage on all. The June sown carrots were re-sampled in January 1957 and were again found free of attack, except on the control plots where the infestation on the roots had now increased to 61.5 per cent. These results confirm those obtained in a previous experiment at Wellesbourne which showed that aldrin and lindane used at dosage rates comparable to those applied on the present experiments and incorporated in the soil, gave an almost complete control of carrot fly. This protection occurred not only in the year when the insecticide was applied, but also in the succeeding year. Tasting tests on carrots from these experiments have shown, however, that in both years those grown in soil treated with lindane showed off-flavour, which ranged from a marked loss of carrot flavour to a disagreeable foreign flavour ('taint'). With those grown in aldrin and the dieldrin-treated soils the flavour was found to be comparatively little affected. (See below).

Experiments were also carried out on early sown carrots at Wellesbourne and Chatteris using seed dressings for the control of carrot fly. At Chatteris, endrin (2 oz. or 4 oz. of 50 per cent dressing per 1 lb. seed) was almost ineffective whilst lindane (1 oz. of 75 per cent dressing per 1 lb. seed) gave a partial control of the first generation but no measurable control of the second generation. At Wellesbourne, where first generation attack was almost absent, endrin, dieldrin and lindane dressings all gave some reduction in second generation infestation, the effect being most marked with lindane. This confirms previous findings on the comparative effectiveness of seed dressings in fen and mineral type soils.

EFFECT OF INSECTICIDES ON CROP FLAVOUR

(D. W. Wright and Dorothy D. Bowe)

Samples of carrots from the various experiments carried out at Wellesbourne and Chatteris in 1956 have been tasted to determine the effect of insecticidal treatments on crop flavour and quality. The samples were cooked and served as a puree to a panel of 8 to 12 tasters who were asked to rate both their flavour and sweetness in relation to a known control. Because of the considerable promise shown by soil treatments as a means of controlling carrot fly, many samples were tasted from the plots treated with insecticides at both centres. At Wellesbourne, lindane applied at the rates of 1 and 2 lb. per acre caused slight to strong musty off-flavours ('taint') in early sown carrots tasted both in August and November, and in late sown carrots tasted in December. The effect was greater with the higher dosage rate and in certain tests there was also a significant loss of sweetness compared with the controls. The dieldrin and aldrin soil treatments used at Wellesbourne in 1956 (see above) caused much less

effect on carrot flavour and no taints were detected. However, samples from these treatments were usually distinguished from the untreated samples by having suffered slight loss of flavour or sweetness. This effect was most marked with carrots from the aldrin 4 lb. per acre plots tasted in July. Samples tasted from the Chatteris insecticide-treated plots showed that, on the early carrots (tasted in November) and the late carrots (tasted in December) only the high dosage level of lindane (4 lb. per acre rate) caused taint. The lower dosage rate, however, caused some loss of flavour. No taints resulted from the use of aldrin or dieldrin. Both insecticides, however, tended to cause slight loss of flavour, expecially aldrin used at the rate of 4 lb. per acre.

Before soil treatments can be confidently recommended for the control of carrot fly, much further work is required on the effects of the various insecticides on carrot flavour and on the degree of insecticide uptake by the crop.

LETTUCE ROOT APHID (J. A. Dunn)

During 1956, root aphid infestations on summer lettuce were slight and insufficient to cause noticeable crop damage. The low numbers were due to cool, wet weather at the time when the aphids were migrating from poplar and establishing themselves on lettuce, and also to an intense attack by predators (*Anthocoris* spp.) on the aphids before they were able to leave the galls on poplar. It was estimated that, in the vicinity of Wellesbourne, Anthocorids cut down the potential migrant aphid numbers by more than 90 per cent.

A field experiment using endrin as a seed dressing and as seedling sprays and dusts, was made on summer lettuce. However, the root aphid population was so small and scattered that no valid conclusions could be drawn on the relative efficiencies of the different treatments. The effect of storage on lettuce seed dressed with endrin was investigated. No phytotoxic effects resulted from dressing the seed with an equal weight of an endrin 50 per cent dust concentrate, providing that the seed was sown almost immediately. When the dressed seed was stored, the germination was very adversely affected.

Experiments were carried out with various varieties of lettuce to assess their relative degrees of resistance to root aphid attack. These experiments confirmed that certain varieties of lettuce (1) were resistant to root aphid attack, but because of low aphid numbers it was not possible to measure the degrees of resistance shown by these varieties. A technique for testing varietal resistance, independent of natural aphid infestations is being developed.

The possibility that wingless aphids may overwinter in the soil and infest another lettuce crop grown on the same site in the following year was investigated. Land which had carried a heavily infested crop of summer lettuce was used. Soil samples taken at intervals during winter showed that, despite the absence of a living host, small numbers of aphids persisted until the spring. The land was dug and surface cultivated at the end of March and then planted with lettuce seedlings. In June, before the winged root aphid had begun to migrate from poplar, 26 per cent of the plants were found to be infested with aphids and several of these carried high populations. Lettuce of similar age grown nearby on plots which had not been cropped with lettuce in the previous year, were found to be free of infestations. Where lettuce root aphid is a problem, therefore, it is inadvisable to take successive lettuce crops from the same land.

CARROT FLY ON PARSNIPS (G. A. Wheatley and J. A. Hardman)

Observations were continued on the biology of *Psila rosae* F. attacking parsnips and, as in 1954, the larvae of the second generation did not cause appreciable damage to the main root of the parsnip until the beginning of November 1955, despite the contrasting seasonal conditions. During December and January damage to the roots was observed to increase approximately threefold although low temperatures prevailed. Thus it appears that much of the damage to the roots could be prevented by lifting and clamping or disposal of the crop before mid-November, where possible.

Experiments on the control of the pest showed that earthing up the rows of parsnips tended to discourage the fly from attacking certain roots but did not reduce the damage on those roots which were attacked. Dieldrin sprays applied to the soil along the rows were not very effective. They appeared to reduce partially the amount of damage on a mined root but did not markedly reduce the number of attacked roots. However, when spraying was followed immediately by earthing-up a 70 per cent control of the pest resulted, providing that the treatment was applied before the middle of August. The poor control afforded by sprays alone was attributed to the very dry state of the soil at the time of treatment.

Since seed dressings are now being used as a supplementary method for the control of carrot fly on parsnips, a study was made in the glasshouse on the effect of gamma BHC and dieldrin seed dressings on the germination of parsnip seed (var. Offenham). They were applied with resin alcohol sticker at rates of 1, 2 and 4 oz. of active ingredient per 1 lb. of seed. The total percentage germination was unaffected by the seed dressings but a slight delay occurred in the time needed for a given degree of germination. The sticker alone increased the germination time by three days, the 1 oz. rate by three and a half days and the 2 and 4 oz. rates by four and a half days approximately. It seems probable that this effect could be more pronounced in the field if semi-drought conditions prevailed after sowing.

Glasshouse experiments using carrots have shown that the newly hatched carrot fly larvae may first feed obligatorily on the fibrous lateral roots and that they do not mine in the main root until a later stage. When carrot fly eggs were transferred to pots containing lettuce and chrysanthemums, no larvae survived to maturity. However, nearly full-grown larvae transferred to the same plants were able to complete development and pupate.

Pot experiments, designed to investigate the mode of action of dieldrin in the soil, have indicated that it is most effective when applied before the eggs hatch. This agrees with the results of field experiments and is the basis of recommended practice for the control of carrot fly on carrots. In the laboratory, dieldrin has been found to be not only more toxic than DDT to the adult carrot flies but also to persist longer at 70°F. Dieldrin should, therefore, be superior to DDT as a foliage spray against the adult flies.

The effect of a series of constant temperatures on the viability and rate of development of carrot fly eggs has been investigated in the laboratory. The theoretical threshold temperature was approximately 38°F. and the time required for development and hatching varied from 28.7 days at 45.0°F. to 4.7 days at 80.0°F. In the field the eggs could be expected to take about 7-12 days to hatch depending on prevailing temperatures. The hatch of eggs laid in the laboratory rarely exceeded 60-70 per cent and was not significantly affected by the temperature during the development.

PEA MOTH (G. A. Wheatley and J. A. Dunn)

The effect of temperature on the rate of development of the pea moth larva during the winter period was further investigated both in the laboratory and in the field. Particular attention was paid to the temperature requirements needed to terminate larval diapause.

Pea moth material was collected directly from peas grown at Wellesbourne. Immediately after collection in August, some of the cocoons were subjected to a series of constant temperatures in the laboratory. The remainder were stored at ambient insectary temperature, which was recorded. Batches were removed at monthly intervals during the period September to March and were placed in a series of constant temperatures for further development. The results showed that diapause in the population ended gradually during the period up to mid-January. This agrees with and can be explained by the recently developed theories on the hormonal control of insect diapause. It was also found that material collected from a stack site in Bedfordshire in October, November and December was, in behaviour, similar to but more variable than the Wellesbourne material.

Field plots kept fallowed and others bearing spring wheat were again set up and

continuous soil temperature records taken. As in 1955, moths emerged earlier from the plots kept free of vegetation.

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THE CONTROL OF THE CABBAGE STEM WEEVIL IN BRASSICA SEED-BEDS

By D. W. WRIGHT and J. S. BUXTON

The cabbage stem weevil (*Ceuthorhynchus quadridens* Panz.) attacks spring sown brassica plants especially those sown in seedbeds. Eggs are laid in the stems and leaf petioles of the young seedlings and the larvae first feed below the epidermis forming mines clearly visible externally as dark ramifying lines. The later stages of larval development are usually completed in the pith of the stem which may be completely eaten away, as many as 14 weevil larvae having been found together in the hollowed out stem of a single seedling. Such severely attacked plants usually succumb, but those less heavily infested frequently have spongy stems which snap readily when the plants are being lifted from the seed-bed or are being transplanted. Infested plants re-commence growth much more slowly after transplanting than those not infested. Occasionally plants are set out containing many immature larvae. As these develop the affected plants are stunted and subsequent growth of the crop is very uneven and many plants may be lost. The larvae occasionally penetrate to the apex of the stem killing the growing point, thus causing the plant to become 'blind'. When fully fed the larvae leave the plants and pupate in the soil.

Although little work has been done so far on the control of this insect, recent investigations at Wellesbourne have shown that it may be readily controlled. In a replicated experiment with summer cabbage in 1955, a 0.02 per cent lindane suspension, applied in a band along the rows when the seedlings were in the second to third true leaf stages, gave 98 per cent uninfested plants. A seed dressing containing 75 per cent lindane was also very effective. When used at the rate of 1 oz. of the dressing per 1 lb. of seed, it gave 76 per cent uninfested plants whilst the damage on the remainder was slight. The weevil damage was severe in the untreated plots on this experiment and only 7.5 per cent escaped attack. As compared with the lindane treatments, aldrin dust and aldrin and dieldrin suspension treatments, applied to the young seedlings, were all comparatively ineffective.

In 1956, this experiment was repeated using a wider range of seed and seedling treatments. A summary of those used, together with the results obtained, are shown in Table I. The seed was sown in early April and the infestation assessments made in early June when the plants were ready for transplanting. The seedling treatments were applied on 11th May when most of the plants were in the second true leaf stage.

As in the previous experiment, lindane, applied either as a seed dressing or in suspension to the young seedlings, was the most effective insecticide used. Both methods of application gave similar and good results. Dieldrin and endrin seed dressings and aldrin suspension applied to the seedlings were ineffective, whilst a dieldrin suspension gave a very incomplete control.

To determine the effect of weevil damage on subsequent plant growth, samples of plants were taken from certain of the treatments and transplanted. When taking the samples, very severely damaged plants were discarded as it was unlikely that these could have established themselves in the field. One month after transplanting, the plants from the lindane seed and suspension treatments were, on an average, almost twice as large as those from the untreated plots or from the dieldrin seed treated plots. The time taken to reach maturity was correspondingly affected and a far greater number of plants were ready for harvest on the two lindane treatments at the first cutting date than on the other two treatments (see Table II). The weevil damage to the seedlings also affected the total yields, those from the lindane seed treated plots being greater than from the controls by 35.6 per cent. (S.E. = 13.6 per cent of general mean).

TABLE I

Control of cabbage stem weevil in seed-beds
Primo cabbage—Wellesbourne 1956

Treatment number	Insecticide	Concentration of toxicant %	Rate of application	Plants unattacked %
1	Lindane seed dressing ..	75.0	1 oz. per 1 lb. seed	94.7
2	Dieldrin seed dressing ..	50.0	1 oz. per 1 lb. seed	2.7
3	Dieldrin seed dressing ..	50.0	1½ oz. per 1 lb. seed	5.3
4	Endrin seed dressing ..	50.0	1 oz. per 1 lb. seed	8.0
5	Endrin seed dressing ..	50.0	1½ oz. per 1 lb. seed	6.7
6	Aldrin suspension ..	0.06	1 gallon per 30 row yds.	10.7
7	Aldrin suspension ..	0.06	1 gallon per 40 row yds.	5.3
8	Dieldrin suspension ..	0.03	1 gallon per 30 row yds.	33.3
9	Dieldrin suspension ..	0.03	1 gallon per 40 row yds.	28.0
10	Lindane suspension ..	0.02	1 gallon per 30 row yds.	94.7
11	Lindane suspension ..	0.02	1 gallon per 40 row yds.	95.3
12	Nil (control)	—	1 gallon water per 30 row yds.	10.7
13	Nil (control)	—	—	4.0

Significant differences at 5 per cent level :—
Treatments 1, 10 and 11 > 2, 3, 4, 5, 6, 7, 8, 9, 12 and 13.
Treatments 8 and 9 > 2, 3, 4, 5, 7 and 13.
Treatment 8 > 6 and 12.

Although the dieldrin suspension treatment gave only a partial control of weevil in the seed-bed, the cabbage crop produced in the field was comparable both in earliness and yield with that from the lindane treatments. Examination of the root systems

after harvest, however, showed that the dieldrin suspension treatment had also given a partial control of cabbage root fly, which had attacked the crop in the field. With all the other treatments, however, the root fly damage to the roots was comparable to that on the untreated plants and indicated that there was little or no residual effect from these treatments in the field. These results relating to the persistence in the field of insecticides applied on the seed-bed confirm those obtained in 1955 (1) and offer an explanation for the comparatively high yield performance of the plants from the dieldrin seed-bed suspension treatment.

TABLE II

Effect of seed-bed treatments for the control of cabbage stem weevil on the time of maturity and yield of summer cabbage

Treatment number in Table I	Number and weight of marketable heads			
	First cutting (13/8/56)		Second cutting (22/8/56)	
	Number	Weight kg.	Number	Weight kg.
1 (lindane seed dressing) ..	75	107.2	12	15.4
3 (dieldrin seed dressing) ..	38	46.1	48	60.1
8 (dieldrin suspension) ..	70	96.4	12	13.3
10 (lindane suspension) ..	71	87.0	14	16.4
12 (control)	44	51.9	36	38.5

Significance of number of heads taken at first cutting (P=0.05). Treatments 1, 8 and 10 > 3 and 12.
There were 90 plants in each treatment but a small number of these in each case did not produce marketable heads.

Although both the lindane treatments used in these experiments have proved effective in controlling stem weevil, the seed treatment is preferable because of the greater ease with which it may be carried out and its lower cost. The seed treatment has also been shown to be of considerable value in reducing cabbage root fly damage occurring in seed-beds (2) and to give substantial protection to young seedlings against flea beetle (*Phyllotreta* sp.).

This triple purpose treatment may therefore be regarded as a valuable routine measure to be used on almost all brassica crops sown either in seed-beds or in the open field. It is not recommended, however, for use on radishes or on turnips grown for human consumption as the flavour of the roots may be adversely affected.

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PLANT PATHOLOGY REPORT

By W. G. KEYWORTH

CROOK ROOT OF WATERCRESS (J. A. Tomlinson)

During 1955-56, laboratory and field studies were made on the effects on crook root infection of the addition of chemicals to the water. The field tests were made in miniature experimental beds at Bere Regis, Dorset (8), and also in commercial-sized beds. Three substances were tested : (i) zinc, (ii) chlorine, and (iii) calcium bicarbonate.

(i) *Zinc.* Previous work had shown that infection was suppressed by traces of zinc in the laboratory tap water at the N.A.A.S. sub-centre at Wye. Further tests using zinc sulphate showed that a concentration as low as 0.5 p.p.m. (parts per million) of zinc would control the disease. The use of soluble zinc compounds in cress beds was found to be impracticable, however, in view of the large quantities of water flowing through the beds (3-500,000 gallons per acre per day). A search was made, therefore, for a relatively insoluble substance containing zinc which could be applied to the whole bed and which would liberate zinc for a long period.

During 1954, experimental quantities of *zinc frit*, a finely powdered glass containing 23 per cent zinc oxide, were made for our use by a firm of vitreous enamel manufacturers. This material is very insoluble but liberates the zinc slowly in water, and in the laboratory it was found that it would suppress infection when added at the rate of 0.05 gm. per 350 ml. of distilled water. Glass frits containing other metals did not control infection, nor did the basal glass compound, thus indicating that the effect of the zinc frit was due to its zinc content and not to the other glass constituents. This fact was further substantiated by tests with zinc oxide which controlled infection at an amount of 0.01 gm. per 350 ml. of distilled water.

Following these tests, field trials of zinc frit were started in September 1955 in the experimental beds and in January 1956 in commercial beds. The frit was dusted on to the surface of the crop at the rate of 1 lb. and ½ lb. per sq. yd. after draining the beds. It was then washed off the plants and on to the floor of the bed when, after allowing the frit to settle, the water supplying the beds was re-admitted. It was not found possible to apply zinc frit without stopping the water, since it was readily washed away. Some 4-6 weeks after the frit application the treated beds, or sections of beds, began to grow more strongly than the controls, and they also showed very much less crook root. This reduction in disease and improvement in crop was maintained for periods of up to six months.

The zinc content of the plants in the treated beds was somewhat higher than that of the plants in the untreated beds ; but the plants were still quite safe for human consumption. The zinc content of the outflow water from treated beds was less than that found to be toxic to fish in hard waters (5) such as supply most watercress beds. The use of zinc frit thus provides considerable promise of a practical control measure.

More extensive trials are being made in 1956-57 and these should indicate whether the material is likely to prove suitable for commercial use. Experiments are also in progress to find how the zinc in the frit comes into solution and to study the mechanism of disease suppression.

(ii) *Chlorine.* Using standard commercial equipment, chlorine gas was fed into an experimental watercress bed. At concentrations of 0.05–0.1 p.p.m. chlorine in the inlet water the disease was completely controlled. Unfortunately, however, the substance had marked toxic effects on the plants which, during the period of treatment, remained stunted and grew very slowly. Owing to the fact that smaller quantities of chlorine cannot be supplied by the standard equipment it was not possible to test the effects of lower doses. It seems unlikely, however, that the method will be of practical use.

(iii) *Calcium bicarbonate.* In continuation of the 1954 experiments (8) which showed that infection could be suppressed by increasing the calcium bicarbonate content of the test waters to 500 p.p.m., a trial was made in one of the experimental beds. The water (calcium bicarbonate content 350 p.p.m.) was charged with carbon dioxide and then passed through a large concrete tank containing limestone chippings. Solution of some of the limestone by the carbonated water increased the calcium bicarbonate content of the water entering the bed to 500 p.p.m., which fell to 400 p.p.m. at the outlet 22 yards away. There was a striking increase in the vigour of the treated plants and the disease was completely eradicated. Unfortunately, the cost of the carbon dioxide was too great for the treatment to be of commercial use.

Further studies on calcium bicarbonate are designed to investigate the mechanism of its action and to determine whether this is due to the calcium or to the bicarbonate ion.

MOSAIC DISEASE OF WATERCRESS (J. A. Tomlinson)

The principal objects of the work have been to discover the effects of the virus on the growth of watercress, to make further studies of its host range, to identify the insect vectors and to suggest control measures.

Some progress has been made in all of these aspects of the work and the main facts discovered are briefly as follows :—

(*a*) Virus infection can greatly reduce the vigour and cropping power of watercress. This has been shown not only in the laboratory but also in the field. In one trial of clonal green watercress (*Nasturtium officinale*) several hundred plants were infected artificially with the virus and a similar number left uninfected. The healthy plants grew vigorously and were multiplied at least ten times in three months. The infected plants, however, were stunted, could not be multiplied and eventually died. This may possibly have been an extreme instance owing to the selection of a highly sensitive clone of watercress but it illustrates the possible potential effects on the yield of the crop.

(*b*) Further tests have extended the known host range of the watercress virus. In addition to the hosts mentioned previously (9), transmissions were also obtained to petunia, *Gomphrena globosa*, and zinnia.

(*c*) The virus was found to be transmitted by *Brevicoryne brassicae*, *Aphis fabae* and *Myzus persicae*. Attempts to transmit the virus by mustard beetle, flea beetle and two species of froghopper found on watercress, were unsuccessful.

(*d*) Seedlings raised from seed taken from systemically infected watercress plants have been shown to be free from virus. It would thus appear that the immediate cure of the disease is the removal of old virus-infected stocks and their replacement with seedlings or with cuttings from healthy seed-raised plants.

SILVERING DISEASE OF RED BEET (W. G. Keyworth and J. Sheila Howell)

The causal organism. Further studies on the bacterium that causes this disease showed it to be a new species. It has been named *Corynebacterium betae* and a description of it has been published together with an account of some of the preliminary work on the disease (6).

Spread of the disease. Observations on experimental plots have shown that the disease can be found in the spring at least 25 yards away from initial autumn infection foci. Spread may occur, in fact, to much greater distances than this, and it is obvious that new steckling beds should be located as far as possible from current season infected seed crops. The disease was found in 1956 in a seed crop of mangolds, there being at least 10 per cent of infected plants. This crop may thus provide another source of the disease on farms.

Attempts to control the spread of the disease by spraying the steckling beds with streptomycin, colloidal copper, or thiram, were unsuccessful.

Seed treatment. The small scale experiments at the N.V.R.S. were continued in 1956, both to assess the final results of the 1955 treatments and to study other compounds. During the autumn of 1955 it was noted that the streptomycin treatment of infected seed (soaking for 24 hours in 0.02 per cent solution) had eliminated most of the initial infections. After the plants were put out in March 1956 and grown on for final recording, however, it was found that considerable spread of silvering had occurred from plot to plot during the winter. This was indicated by the fact that the control plots grown from uninfected seed contained up to 20 per cent silvering. It was not possible, therefore, to assess the effects that the treatments would have had on the final stands of the seed crop if the plants had been raised in isolation.

More satisfactory results were obtained from the trials on farms where better isolation of the stecklings grown from treated seed was usually possible. The results were variable but in every case the treatment resulted in a very considerable reduction in disease and in consequent satisfactory stands.

Disease incidence in the treated crops was never higher than 3 per cent, whereas in the untreated crops 10–66 per cent infection was recorded. In one large experiment the stecklings from the treated and untreated seed were grown about a mile apart, and the danger of cross infection was thereby reduced to a minimum. Four acres of seeding plants were grown from each batch of stecklings. When finally recorded in late June 1956 the untreated crop contained 66 per cent and the treated crop 0.14 per cent of silvered plants.

Promising results have been obtained in both 1955 and 1956 by dressing seed with a proprietary mercurial compound, 'Harvesan' (1 lb. to 100 lb. seed). While it is possible that this method will not be quite so effective as the streptomycin treatment, it has reduced the disease very considerably. It seems likely to give a satisfactory commercial control and it has the advantages that the material is readily available (whereas streptomycin is not) and that the dry treatment is easier to carry out than soaking in liquid.

STEM AND FRUIT ROT OF OUTDOOR TOMATOES

(Dorothy E. Fisher and J. M. Way)

The cool, wet summer of 1956 encouraged the growth of the fungus *Didymella* which causes this disease, and very successful infection experiments were made. Most of these were tests of fungicides to control the disease in the field. Other studies were in continuation of those described in the previous report (4).

Fungicide tests. Compounds were first selected in the laboratory for their toxicity to *Didymella* growing in culture. The selected compounds were further tested for toxicity to young tomato plants. Promising compounds were then subjected to field tests in which their ability to serve as eradicants or protectants was assessed by spraying them on to leaf scar wounds. In the eradicant tests the leaf scars had already been inoculated with spores at various intervals beforehand. In the protectant tests the spores were applied at varying times after the fungicides. Each test was made on 105 leaf scars. As far as possible the fungicides were applied to the stems only, a special lance with two opposing nozzles being used both for fungicides and for spores. Since the stems are fairly resistant to chemical damage, higher concentrations could be used than could have been applied to the leaves.

Of the compounds tested, 3 per cent formulations of various derivatives of dithane proved most effective, both as eradicants and protectants. Captan (0.5 per cent) and thiram (0.8 per cent) were good protectants but were not effective as eradicants. The tests have not yet reached the point where any practical recommendations can be made but it is clear that at sufficiently high concentrations some compounds will probably control the spread of the disease.

Seed infection. 1956 provided an opportunity for a test of seed transmission under conditions favourable for disease expression in the field. No infection occurred, however, in a total of 315 plants grown from three different batches of heavily infected seed and one of clean seed. It is thus apparent that under the conditions of this

experiment the disease was not carried over to the mature plants from the seed. This confirms the findings of Philipps (7). It must be emphasised, however, that this test does not mean that such transmission can never occur since it is conceivable that different methods of raising the seedlings may influence the carry-over of the disease. This is to be further investigated.

Overhead irrigation. Tests were made in 1955 and 1956 of the effect of overhead irrigation on the spread of the disease.

In both seasons the use of oscillating spray lines increased the spread from artificially inoculated plants. In the irrigated plots in 1955 and 1956 there was, respectively, 10 per cent and 12 per cent secondary infection compared with 0 per cent and 3 per cent in the control (non-irrigated) plots containing the same numbers of infected plants.

Soil contamination. A three-year test of the effect on the succeeding crops of burying infected haulm and fruit was concluded this season. Infection was heavy in 1954 (average 42 per cent), eight months after the haulm, etc. had been buried, very slight (average 0.5 per cent) in 1955, and nil in 1956. This result suggests that the pathogen eventually disappears from the soil but shows the advisability of a rotation with at least a two-year interval if *Didymella* has been present in a crop.

Perithecial stage. Perithecia of *Didymella* were again found in November 1956 on the holding at Alcester, Worcestershire, where they were previously discovered in 1954 (3).

Tests for resistance. Several species and varieties of *Lycopersicum* were again tested for resistance to the disease. One strain of *L. hirsutum var. glabratum* showed high resistance to both stem and root infection. Only seven plants were available for test, however, and thus it is proposed to make further tests on larger numbers of vegetatively propagated plants.

PARSNIP CANKER (A. G. Channon)

A major part of the work on this disease in 1955-56 has been devoted to a study of a species of the fungus *Itersonilia* which was isolated from infected roots growing in several widely separated localities. It has been shown to be highly pathogenic to parsnip roots (2).

This fungus was first isolated from parsnip cankers by Wilkinson (11) in the U.S.A. but it has not previously been reported from Britain. While the fungus was obtained in the first place by conventional isolation methods it was found to be isolated much more readily by a special technique used by Wilkinson. In this method, portions of infected root are suspended over a suitable nutrient medium. The spores of the fungus are shot off and develop into cultures which are relatively free of the many other organisms present in the rotted tissue. This method has been adopted as a standard procedure and isolates of the pathogen have now been obtained from localities as far apart as Kent and South Wales.

Itersonilia enters very readily through artificial wounds in the roots but it will also infect through tissue that has not been deliberately wounded. It causes a purplish-brown to black, often orange flecked, lesion which is identical with many found on naturally affected roots. It is not apparently directly associated with the purely orange or orange-brown lesions that are also found on parsnip roots and the cause of such lesions is still unknown. It will also infect parsnip leaves, causing small greenish-yellow spots, often with necrotic centres. The leaf infections have not yet been found extensively in the field, however, although reported to occur in the U.S.A. Their significance in the life history of the pathogen is thus not yet clear.

Since the 1954 trials on the relation between carrot fly injury and parsnip canker, reported last year (1), two further experiments have been made on this subject. In 1955, similar dieldrin treatments to those used in 1954 were again employed to reduce carrot fly infestation to a very low level. Although the incidence of canker throughout the whole experiment was much lower than in 1954, it was again evident that the reduction in carrot fly attack was not accompanied by a corresponding reduction in canker.

In 1956 another experiment was made with slightly modified dieldrin treatments. The final liftings in January showed that there were no differences in the amount of canker between the treated and untreated plants. In an October lifting, however, some evidence was obtained that the dieldrin treatment had reduced the amount of canker to a slight extent. The exact significance of this result is not clear but it is apparent that, in all the three years' trials, the control of carrot fly had no effect on the final incidence of canker on the roots in January.

BOTRYTIS DISEASE OF LETTUCE (J. M. Way)

Further tests of fungicides for the control of *Botrytis* disease of lettuce were made in 1956. In a trial of thiram and of T.C.N.B. on frame lettuce growing in their final positions, good control of the disease was obtained with both compounds. Treatment of the soil in the frames before planting out, with mercuric chloride and formalin gave no control.

Another test of the same compounds and also of P.C.N.B. and captan was made on outdoor lettuce grown through the winter in the seed-bed under lights and planted in the field in March. The plants were treated in the seed-bed only (on four occasions) and the effects on field survival were assessed in May. Thiram and captan caused a marked reduction in disease but P.C.N.B. and T.C.N.B. did not.

These results confirm those obtained in 1955 (10) and show that thiram gives a good control of *Botrytis* disease in both frame and spring-planted lettuce.

Acknowledgments

Thanks are due to the many growers, officers of the N.A.A.S., and others who have co-operated in the experiments or placed facilities at our disposal. Special mention must be made of Messrs. Ferro Enamels Limited, Wombourn, Wolverhampton, who manufactured and supplied the zinc frit used in the watercress experiments, and also of Messrs. Wallace and Tiernan Limited who loaned and supervised the use of the chlorination apparatus used in similar trials.

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WEED INVESTIGATIONS

By H. A. ROBERTS

ECOLOGY (Marion E. Smart, H. A. Roberts and J. K. A. Bleasdale)

Observations on some aspects of the germination behaviour of important annual weeds of vegetable crops were continued along the lines described in previous reports. A further experiment on the effect of soil compaction and degree of fineness of tilth on weed emergence was carried out and a trial to determine the advantages of harrowing in one flush of weeds before sowing a crop was repeated.

The results are now available for the second series of samples from the plots of the long-term experiments maintained by the Chemistry Section (2). These show that during the first year of vegetable cropping the population of viable weed seeds buried in the soil was reduced by more than 50 per cent. They also show that the extent to which this reduction occurred was different for different weed species. A further series of samples from each of the three experiments was taken in the autumn of 1955. These, in conjunction with the previous samples, will demonstrate the overall effect of vegetable cropping in reducing the buried seed population of an initially very weedy field. In future, more detailed samples will be taken from individual experiments in order to evaluate treatment effects.

COMPETITION STUDIES (J. K. A. Bleasdale)

Experiments designed to determine the quantitative relationship between the amount of weed present in a crop and the crop yield have been continued and a preliminary report published (1). Data have been obtained which indicate that relatively small amounts of weed can cause considerable yield depressions. The statistical analysis of data from this type of experiment presents certain difficulties which have not yet been overcome.

The effect of soil fertility on the competitive relationship between crops and weeds has been studied in preliminary experiments. These have included observations on the growth response of certain weeds to different levels of fertility.

An experiment was carried out with maincrop onions to determine the effect of removing the weeds at different stages of growth on crop yield and quality. The earliest date of weeding, one month after the emergence of the onions, gave the highest total yield and best crop quality. The relationship between weed stand and the time taken to remove them by hand was also studied in this experiment which will be repeated in 1957.

The experiment on the time of weed removal from early carrots grown under Dutch lights (3) has been repeated. On plots which were weeded only once, the highest yield was obtained by weeding 42 days after carrot emergence, the yield being 75 per cent of that on plots which were kept weed free throughout. Plots weeded 28 days after the emergence of the carrots, which in 1955 gave the same yield as the weed-free plots, this year yielded only 63 per cent of the clean weeded plots. Detailed observations were made throughout the growth of the crop which will enable an interpretation of the different results in the two seasons to be put forward.

CHEMICAL CONTROL (H. A. Roberts)

During 1956 an attempt was made to gain as much information as possible regarding the use of dinoseb as a selective post-emergence herbicide for the control of annual weeds in crops of market garden peas. Two pot experiments and two field trials were carried out to compare the effects of dinoseb (ammonium) and dinoseb (amine) on the growth and yield of different varieties of peas. The results were in line with previous work and clearly showed the greater selectivity of the amine formulation. Whilst differences between the two were slight as regards control of weeds, in all the experiments the amine caused less scorching of the crop and less check to growth than did the ammonium salt. The response of twelve varieties of peas to dinoseb (amine) was determined in observation trials and the effect on yield was

measured in a trial with five varieties. This trial was repeated at Efford, Luddington and Stockbridge House E.H.S., the response of three varieties commonly grown in the particular area being compared with that of two varieties included in all the trials. The effect of spraying at very early stages of crop growth was also investigated at Wellesbourne.

Weed control in these experiments was consistently good, and even when the herbicide was applied at a rate equivalent to 3.0 lb. of dinoseb per acre, crop injury and yield reduction were negligible. Only in one instance, in a clean crop at Luddington, were significant yield reductions obtained. At the time of spraying this trial, temperature and humidity were high, whilst the pea growth was 'soft' and, in practice, the application rate would be reduced under these circumstances.

Slight, but consistent differences in response to dinoseb (amine) were detected amongst the early varieties, but these did not appear to be sufficiently large to be of practical importance. No consistent differences were found amongst the maincrop varieties. The results as a whole therefore confirm the view previously expressed (3) that dinoseb (amine) is a very effective treatment for the control of many annual weeds in market garden peas. The evidence suggests that pea crops can be sprayed at an early stage, even when only one expanded leaf is present, so that it is possible to time the application to obtain maximum weed control without fear of crop injury.

Field trials with the substituted phenoxybutyric acid herbicides (3) showed that peas and celery were two of the most tolerant vegetable crops. In further trials, MCPB (2-methyl-4-chlorophenoxybutyric acid), as the sodium salt, was applied to a number of pea varieties. Whilst no serious yield reduction occurred with rates of up to 3.0 lb. acid-equivalent per acre, it again appeared that this material is likely to have only very limited use in pea crops because of the poor control of some of the commonest weed species. Two small trials with MCPB were carried out on self-blanching celery grown in Dutch lights in order to determine the effect when sprayed at the seedling stage. In one of these trials, marked root abnormalities were found in plants from treated plots, and these also appeared in plants sprayed in a pot experiment.

Two experiments on the use of monuron (3-(p-chlorophenyl)-1, 1-dimethylurea, formerly known as CMU) for annual weed control in established asparagus were continued and a third was begun at Paglesham. No adverse effects on yield or quality were detected as a result of applying monuron at 2 lb. per acre in two successive years, and weed control was again very good. One trial, however, did demonstrate in a striking manner the rapidity with which high populations of resistant species can build up with continued use of monuron. In 1955, only a few plants of speedwell (*Veronica persica*) were present, but these flourished and set seed, so that in 1956 the treated plots were carpeted with this species. A further small trial with monuron applied as a pre-emergence spray to an asparagus seed-bed confirmed those reported previously in that rates of 0.5 and 1.0 lb. per acre gave excellent control of annual weeds without affecting emergence or growth of the asparagus seedlings.

Among other trials carried out during the year may be mentioned two in which the efficiency of monuron and sodium chlorate was compared for the control of mixed weeds at the base of fences. Further records from these will be obtained in 1957. Experiments to test the possibility of using dinoseb (amine) as a residual pre-emergence herbicide for large-seeded crops were conducted with broad, runner and spring-sown field beans. These trials also yielded information of value to the study of weed competition, and they will be extended in 1957. CIPC (isopropyl N-(3-chlorophenyl) carbamate) was included in several trials in an attempt to find a herbicide for the control of chickweed (*Stellaria media*) and annual meadow grass (*Poa annua*) in onions, and in transplanted spring cabbage, whilst preliminary field tests were also carried out with several herbicides newly available in 1956 in order to determine their possibilities for use in vegetable crops.

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STATISTICS REPORT

By J. A. NELDER

The Statistics Section has been invited by members of other Sections to consider the statistical aspects of a multitude of research problems during the year, ranging from the sampling of a watercress bed for disease assessment to the analysis of the results of tasting carrots for taints caused by insecticides. The most common analytical techniques on which advice has been sought have been the transformation of data prior to using the analysis of variance, the analysis of covariance, and variance component analysis.

FIELD EXPERIMENTAL TECHNIQUE (J. A. Nelder and D. Cooke)

Further work has been done on possible methods of improving accuracy in field experiments. The general problem of measuring the experimental error of individual treatments is one that has received relatively little attention (a brief account is given in Quenouille's book (5) pp. 263-6, and Ehrenburg (1) has discussed the problem). An extension of Quenouille's method is being developed which it is hoped will allow information on treatment variances to be extracted from an experiment of given size, and will give a firmer basis for applying the results to plot sizes other than those used in the experiment itself.

Early summer cauliflower : effects of size at planting out on size at harvest, and on maturity date

Another experiment was carried out using the cauliflower variety Finney's 110, in which plots containing plants taken as they came from the frame, were compared with plots in which plants of different sizes, divided into six grades, had been planted in suitable proportions, the same for each plot. Other plots contained plants of the six size grades grown separately. From the yields of the latter plots it was possible to calculate the improvement in accuracy attainable by sorting plants prior to planting out, on the assumption that the different size grades were distributed at random in the frame. For total weight this theoretical improvement in accuracy was small, amounting to some 14 per cent, which was in agreement with the 1955 results ; but direct comparison of plots with unsorted and sorted plants gave a much higher improvement from sorting amounting to 216 per cent, though this effect did not quite reach significance at the 5 per cent level, owing to the small number of degrees of freedom for the two variances. The discrepancy in the two results must be attributed to the non-random distribution of size grades in the frame. The results suggest that where it is important to have a representative selection of plants in each plot, as, for example, in a variety trial, preliminary sorting at the planting-out stage might be worth doing to improve the accuracy of the trial. A similar effect could be obtained by planting whole blocks of one size grade.

Hand thinning of carrots

A further experiment was carried out to test whether the hand thinning of carrots was a worthwhile practice to adopt with experimental crops to obtain an improved accuracy in treatment comparisons. Two seed rates were used, combined with a thinning *v.* no thinning treatment. Since thinning affected the yield of the crop, the accuracy of each treatment has been expressed as a relative variance, i.e. variance/(mean)^2, and standard errors can be applied to the (natural) logarithm of the relative variance (abbreviated to LRV). The following results were obtained for marketable and total yield.

LRV	Low seed rate		High seed rate		S.E. of a difference
	Unthinned	Thinned	Unthinned	Thinned	
Marketable yield	—2.767	—3.263	—2.874	—3.266	±0.339
Total yield ..	—3.687	—3.869	—3.914	—3.777	±0.326

There was no effect of seed rate on the LRV for marketable yield, while the effect of thinning was to reduce it although the mean effect was not quite significant (0.444±0.240). On the original scale the effect of thinning was to reduce the relative variance in the ratio 0.641 : 1. Thinning was estimated to increase the labour in this experiment by about one-quarter, though the increase, of course, would vary with the type of experiment being done. On a cost per unit information basis, thinning had an advantage of about 5 : 4. For total yield, on the other hand, the treatments gave no significant differences. On the basis of these results, thinning seems to be of doubtful advantage, except perhaps where the limiting factor is land.

Interpretation of the results of onion variety trials

The assessment of onion variety trials presents peculiar difficulties in that the germination of any batch of seed appears to be greatly influenced by the conditions under which it was harvested. Thus differences in stand, and so in yield, between varieties in a trial may not result from varietal differences at all, but from irrelevant differences in the environment during seed ripening and collection. Finch, of the N.I.A.B., has suggested that this latter type of difference might be eliminated in trials by adjusting all yields to a constant stand, the adjustment being calculated from a regression line of yield on stand obtained by varying the seed rate for a single variety in the trials. This method of adjustment assumes that the yield-stand relationship for each variety is effectively linear over the range encountered in the experiment, and that the slope of the line is the same for each variety ; also that the factors causing differences in stand between the varieties are primarily non-genetic. An experiment was carried out in 1956 in an attempt to verify or disprove these assumptions. Seed of three varieties, Cambridge No. 2 (flat), Bedfordshire Champion (oblate), and Cambridge No. 10 (globe) was obtained from four sources for each variety, seed from one source for each variety being sown at three rates. It was impossible to get seed of each variety from the same four sources, and while the stocks of the Cambridge varieties were quite closely related, those of Bedfordshire Champion were obtained from four seed firms, and so were probably unrelated ; in spite of this lack of symmetry the experiment gave some information on the points at issue. Each plot was split in order to include a watering treatment during the germination period (about four weeks) and four replicates were used. The three varieties differed strikingly in their response to watering, which increased the stand of Cambridge No. 2 by 50 per cent, Cambridge No. 10 by 40 per cent, but that of Bedfordshire Champion by only 12 per cent. The seed from different sources of the same variety gave similar responses to watering, so that the results point to a genetic difference in response to moisture conditions in the seed-bed. It follows, therefore, that this type of variety-watering interaction could make adjustment to a constant stand a misleading method of analysis if applied to a group of experiments on sites of differing moisture status. There were large differences in stand between different seed sources of the same variety, but the most disconcerting feature of the results was the presence of significant differences in yield between two sources of the same variety after adjustment for difference in stand. Such differences were not unexpected with Bedfordshire Champion since the seed sources were different firms ; nevertheless, for this variety the size of these differences

in yield after adjustment for stand was large, amounting to 65 per cent of the mean yield in one instance. However, two lots of seed of Cambridge No. 10 were derived from the same grandparent stock and differed only in that the parent stocks were multiplied at different places, and hence under different conditions ; their yields, after adjustment for stand, differed by 20.0 ± 4.56 per cent of the mean. If such differences were at all common, variety trials would be of doubtful value. Recent work by Plaisted (4), involving the same kind of experiment, does not appear to show this type of effect, and further investigation is needed to show whether it occurs at all frequently.

Effect of cultural treatment of lettuce plants on final variability (D. Cooke)

The experiment to compare the variability in a Dutch light lettuce crop caused by each of three methods of treating plants up to the planting-out stage was repeated. The aim of the experiment was to determine which method may be recommended to experimenters as being the most efficient. The treatments were again (a) pricking out, (b) thinning in the seed-bed, and (c) planting out directly at the two-leaf stage. There were two plots of each treatment per block. The measure of variability used was the mean difference in yield of plots of the same treatment in the same block, expressed as a percentage of the average plot yield of the treatment ; this will be referred to as the percentage variability. The great effect of a small proportion of missing plants on the variability was mentioned in the 1954 Annual Report. To measure this, the variability of the average weight per plant of the marketable lettuce on a plot was determined as well as that of total marketable weight.

The results obtained in the last two years will be considered here. The pricking-out treatment did not give promising results in that it produced a percentage variability, both for average and total weight, at least as high as that of the other two treatments. The thinning treatment gave the same percentage variability for total weight as the direct-planting treatment but a smaller percentage variability for average weight. The discrepancy was caused by there being more losses in the thinning treatment than in the direct-planting treatment. A high proportion of the losses was caused by attacks of *Botrytis* on the mature crop, though the total losses were not large. The results suggest that the plants chosen for the plots of the thinning treatment were less variable than those chosen for the plots of the direct-planting treatment. Thus, the combination of direct-planting with more careful selection at planting time may prove to be a more efficient method than the ones discussed here, and this possibility is being investigated.

POLYGENIC VARIATION (J. A. Nelder)

Further experiments were carried out with varieties of French bean, and the number of varieties used for crossing was increased from four to six, with the intention of applying the recently developed theory of diallel crosses, discussed by Hayman and others (2, 3), to the results. (Four varieties gave an insufficient number of hybrids relative to the number of parents to allow full use to be made of the method). With both seed size and flowering time a non-additive type of pattern has been apparent, whereby the successive F generation means, instead of moving towards the midparent value from the F_1 value, move away from it towards the 'inferior' parent (i.e., that with late flowering time or small seed size). This effect, which is presumably the result of using material which has been subjected to considerable artificial selection in the past, is being further studied, and possible theoretical models to explain it are being investigated.

TASTING TESTS (D. Cooke)

The Station's tasting panel, which is organised by the Entomology Section, has collected a large amount of data since it was set up in 1954. A statistical investigation of these data has been begun with the aim of improving the design and analysis of the tests. The first factors considered were the scoring system, the size of panel, the

number of times the panel should taste and the appropriate statistical tests. It has been found that it is possible to reduce the numbers of tasters from twelve, the number which has normally been used, to eight, with hardly any increase in the standard errors of the treatment comparisons. Also, that the most effective way to decrease the standard errors of treatment comparisons is to increase the number of times the panel tastes the samples (though, of course, a reasonable interval must be left between each tasting). On the basis of these and similar inferences from the past results it has been possible to suggest a number of other improvements in the practice of the tests. Work on the statistical problems will be continued.

WORK FOR OTHER BODIES

Members of the Section continued to serve on several Working Parties of the Agricultural Improvement Council's Experimental Horticulture Committee, J. A. Nelder on the Glasshouse and Protected Cropping Working Parties, and D. Cooke on the Bulbs and Flowers Working Parties. J. A. Nelder has prepared a paper on the results of spacing experiments with lettuce under Dutch lights and cold structures, carried out at the Experimental Horticulture Stations of the N.A.A.S. under the aegis of the Protected Cropping Working Party.

The Section dealt with the design and analysis of 67 experiments for outside bodies during the year, involving 2,784 plots ; these comprised 2,572 plots from the Experimental Horticulture Stations, 148 from other N.A.A.S. experiments, and 64 from research institutes. Assistance with statistical problems has been given to members of the Glasshouse Crops Research Institute and the National Institute of Agricultural Engineering.

J. A. Nelder has written a paper on general aspects of field experimentation, which appeared in the *N.A.A.S. Quarterly Review* (6).

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THE WEATHER DURING 1956

RECORDS OF THE N.V.R.S. CROP WEATHER STATION

By JOSEPHINE I. E. RUBIO, E. J. WINTER and G. STANHILL

In order to extend the usefulness of the weather records in the research work of the various sections, particularly the Irrigation Section, a number of special instruments have been installed at the weather station.

These include a Kipp solarimeter which measures the total amount of solar energy falling on a horizontal surface. Unlike the standard Campbell-Stokes sunshine recorder, which measures the duration of bright sunshine, the solarimeter is sensitive to radiation even when the sun is obscured by cloud. The accuracy of the equipment was determined by the National Institute of Agricultural Engineering as ± 4 per cent. A small thermostatic room has been built adjacent to the weather station to house autographic instruments, including a Seimens electrolytic meter which is used to integrate the output of the Kipp solarimeter.

A metal evaporation tank was installed in July, to replace the brick and concrete one which had been damaged by frost. Daily measurements of the depth of the water, to the nearest 1/100th of an inch, indicate the evaporating potential of the atmosphere during the past 24 hours. Readings from the evaporation tank provide a useful check on the daily calculation of potential evaporation by the Penman method.

Three Garnier-type evapo-transpirometers (1) have been set up to measure the total loss of moisture from a grass-covered soil surface, the soil being kept permanently at field capacity. The three replicate readings agree within ± 5 per cent. Field soils, of course, are not usually kept at field capacity, and so the actual rate of evapo-transpiration from field crops is less than the potential amount indicated by the Garnier instruments. Actual evapo-transpiration is measured by the regular weighing of monolith soil cores on which grass is growing, using special apparatus consisting of a mobile crane and balance. The cores are not sheltered in any way and tests have shown that their soil moisture status is essentially the same as that of the surrounding grass plot which extends from the cores for at least 20 feet in all directions. Measurements are made to the nearest 0.005 inch of rain, and agreement between the three replicate cores is within 5 per cent.

Various workers have shown (2) (3) that the readings given by rain gauges vary with the height of the receiving funnel above ground. At Wellesbourne, discrepancies were noticed between values for rainfall deduced from the evaporation tank readings, and those from the standard rain gauge. A second gauge was installed, therefore, with its rim only one inch above ground level. This gauge was surrounded by a fibre mat to minimise insplashing. The year's rainfall measured with the ground level gauge was 5 per cent more than that measured with the standard gauge. The monthly discrepancies varied from 2 per cent to 19 per cent and the magnitude of the errors was found to be correlated with wind speed. It was concluded that wind eddies caused the standard rain gauge, having its rim one foot above ground, to under-estimate rainfall to an extent proportional to the speed of the wind. Readings obtained from the ground level gauge were consistently nearer to values which would be expected from the evaporation tank readings than those from the standard gauge. Details of this work will be published elsewhere.

The weather during the early part of 1956 was dry. The soil moisture content did not reach field capacity until late December 1955. Even then the maximum soil moisture content was only briefly maintained and very little drainage occurred. The rate of water loss by evaporation rapidly overtook the gain from precipitation, so that a steadily increasing soil moisture deficit arose much earlier than usual. At the end of June, the weather deteriorated, and soil temperature began to fall a month ahead of the average time (Fig. 2). Conditions were generally bad for harvest.

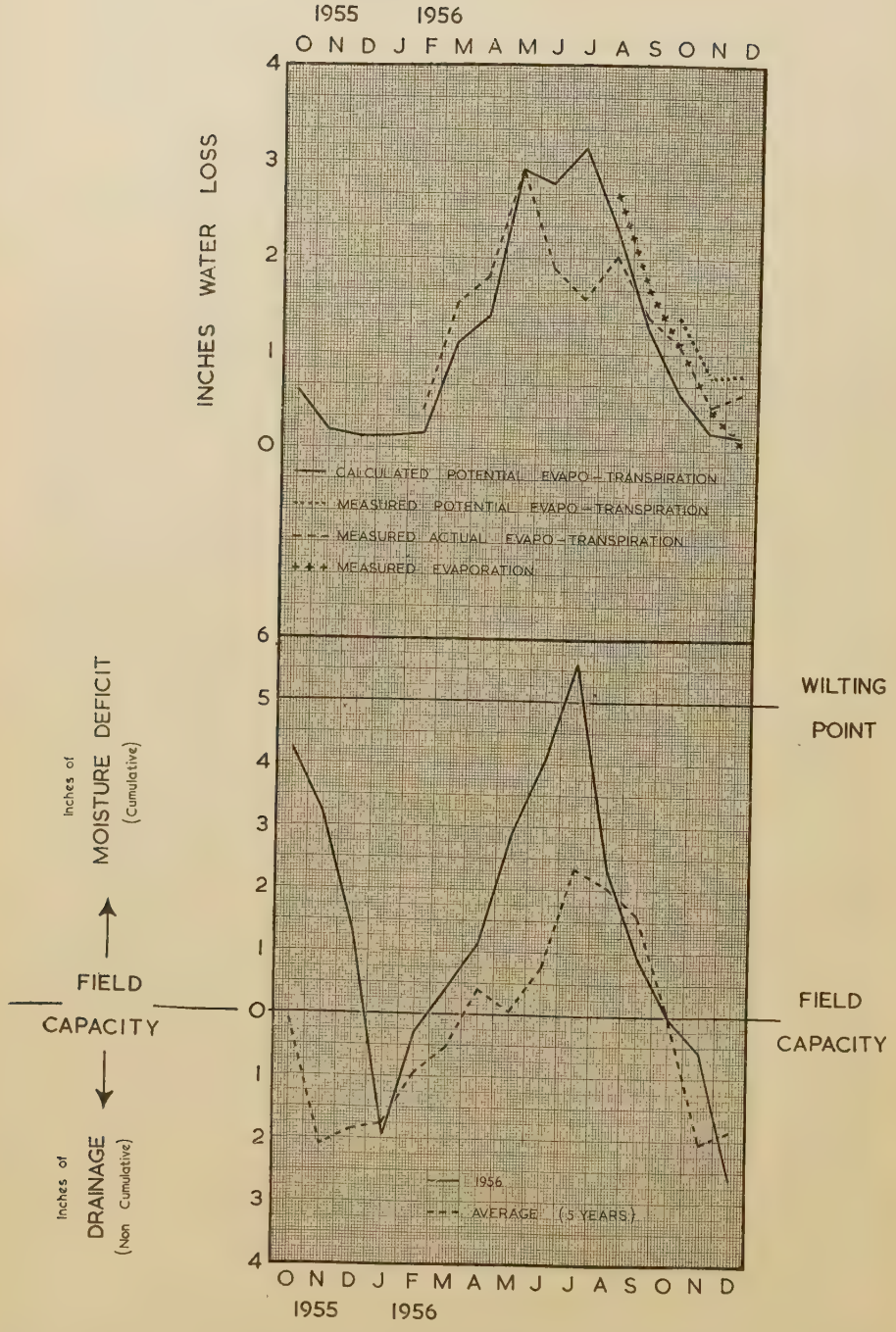

Fig. 1. (*Above*): The potential and actual loss of water by evapo-transpiration from short grass and evaporation from an open water surface.

(*Below*): Theoretical moisture status of a soil completely covered with a green crop.

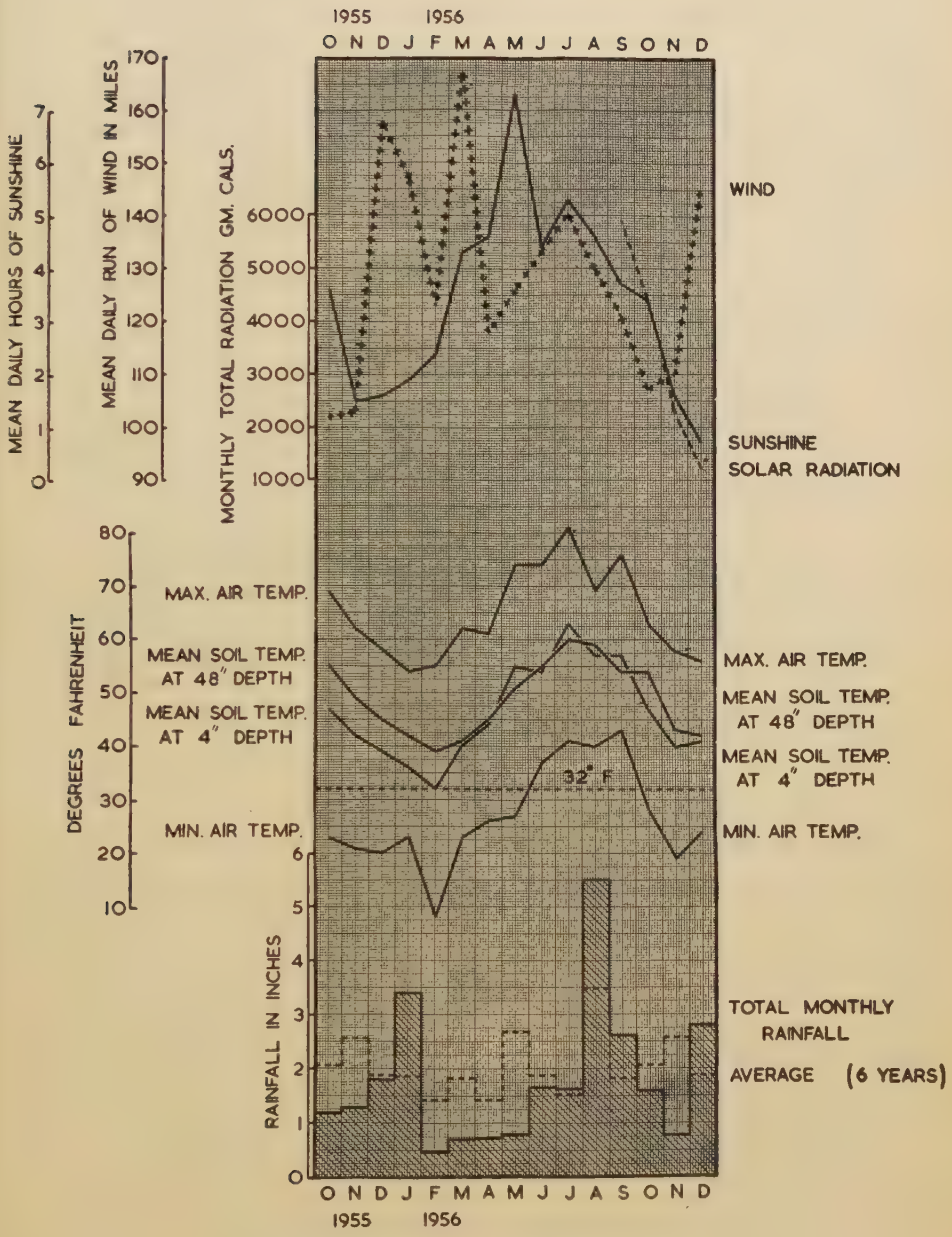

Fig. 2. Summary of weather records at Wellesbourne, 1955/56.

The distribution of rainfall over the past three years has been most irregular. During the twelve months ending July 1954, the rainfall was 24.01 inches ; during the following twelve months it was 31.46 inches, and during the twelve months ending July 1956 it was 13.51 inches. The average of these is 22.99 inches ; the long term average is 24 inches.

The weather records are summarised in the following table and Figs. 1 and 2.

Summary of various weather features during 1956

			*6-year average
Sunshine :	sunniest month ..	May (daily average 7.3 hours)	5.8 hours.
	dullest month ..	December (daily average 0.7 hours)	1.4 hours.
	most in a day ..	14.7 hours on 25th July (93% of possible)	
Rainfall :	wettest month ..	August (5.51 inches)	3.49 inches.
	driest month ..	February (0.46 inches)	1.41 inches.
	most in a day ..	1.11 inches on 29th August.	
	total during 1956 ..	22.65 inches	24.43 inches.
Wind :	windiest month ..	March (daily average run—167.07 miles)	142.81 miles.
	calmest month ..	October (daily average run—107.38 miles)	99.13 miles.
	windiest day ..	1st January (day's run—372.86 miles).	
	calmest day ..	6th January (day's run—5.18 miles)	
	daily average run of wind during 1956—131.78 miles.		
Air temperature :	warmest month	61°F. mean temperature in July	61°F.
	coldest month ..	31°F. mean temperature in February	36°F.
	highest maximum ..	81°F. on 26th July.	
During winter 1955-56 :			
	lowest minimum ..	8°F. on 20th February, i.e., 24° of frost.	
	first air frost ..	24°F. on 16th October 1955.	
	last air frost ..	31°F. on 27th May 1956.	
	number of nights with air frost—90		77
	number of nights with ground frost—123		109

*The averages refer to the corresponding month or period during the previous six years. Thus, in the first entry in the Table, the average daily number of hours of sunshine for May during the past six years was 5.8, but May was not necessarily the sunniest month in every year.

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LIBRARY REPORT

By BRONWYN M. BAGGS

With the appointment of a full-time librarian a number of changes were made in the administration of the library, and a committee was appointed to advise upon questions of policy.

New equipment, including shelving and cabinets, has been purchased to meet the requirements of rapidly increasing stock. The adoption of a visible records system facilitates the recording of periodicals.

Arrears of binding have now been greatly reduced. 275 volumes were sent to the binders during the year.

The library has received a notable gift from Mr. A. A. Clucas of a first edition copy of Gerard's 'Historie of Plants. Bookes I, II and III'.

Holdings

Current periodicals	126
Bound periodical volumes	508
Books	234
Separates	2,849

Reclassification of certain categories of material account for any apparent discrepancies between these figures and those given in the previous report.

Internal loans maintained a steady figure and loans obtained from other libraries numbered 190.

PUBLICATION RECORD

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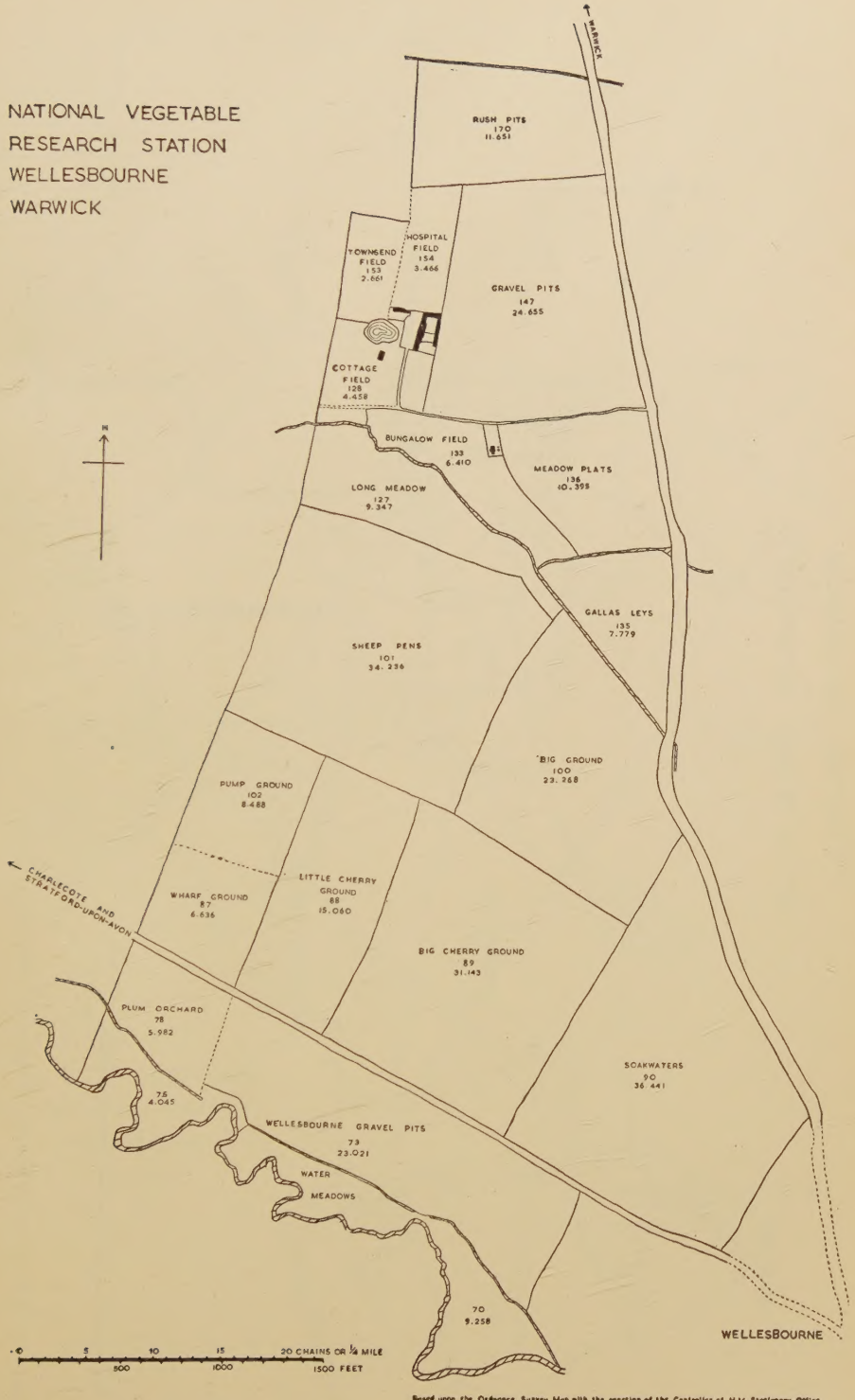

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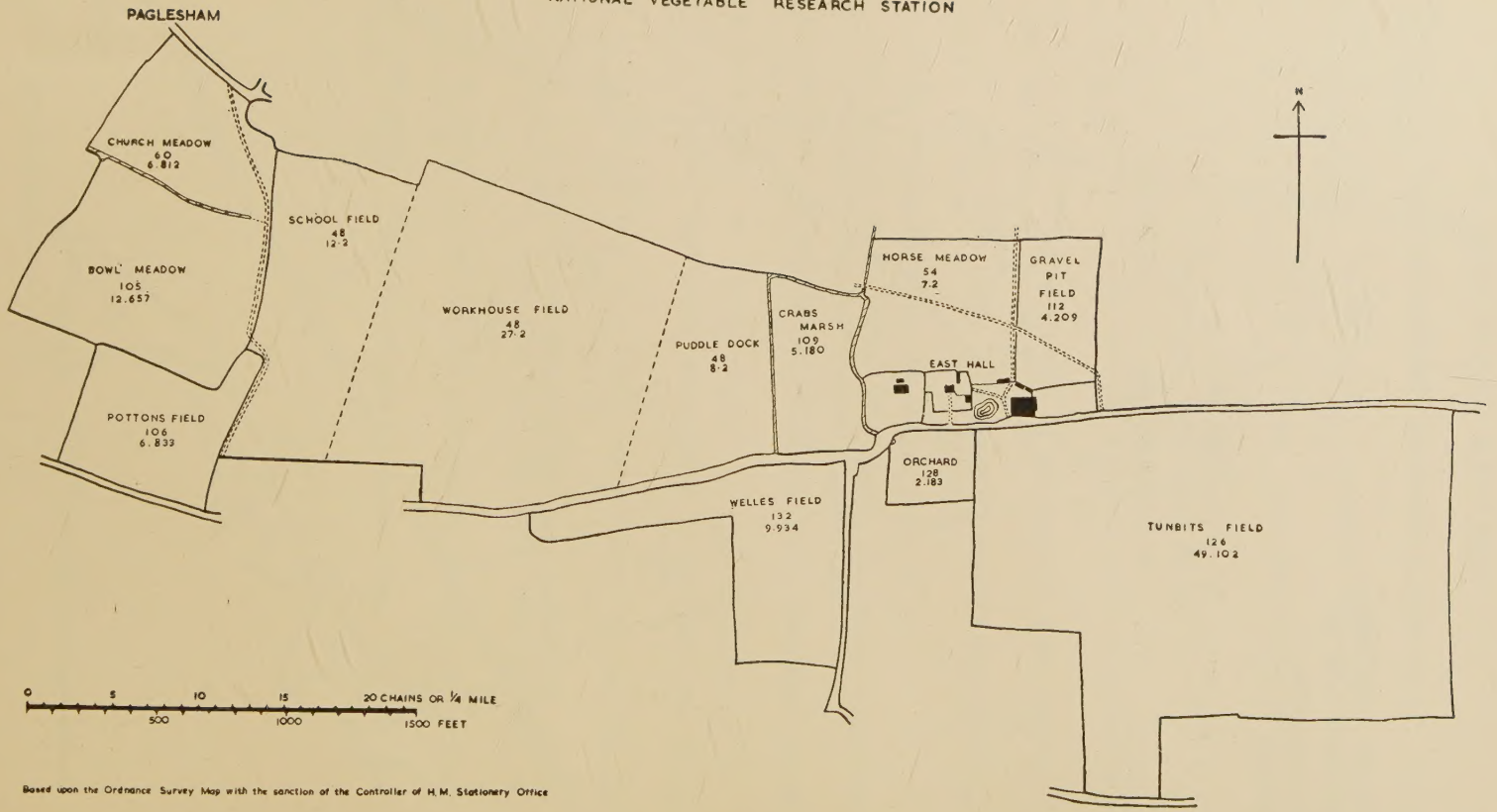

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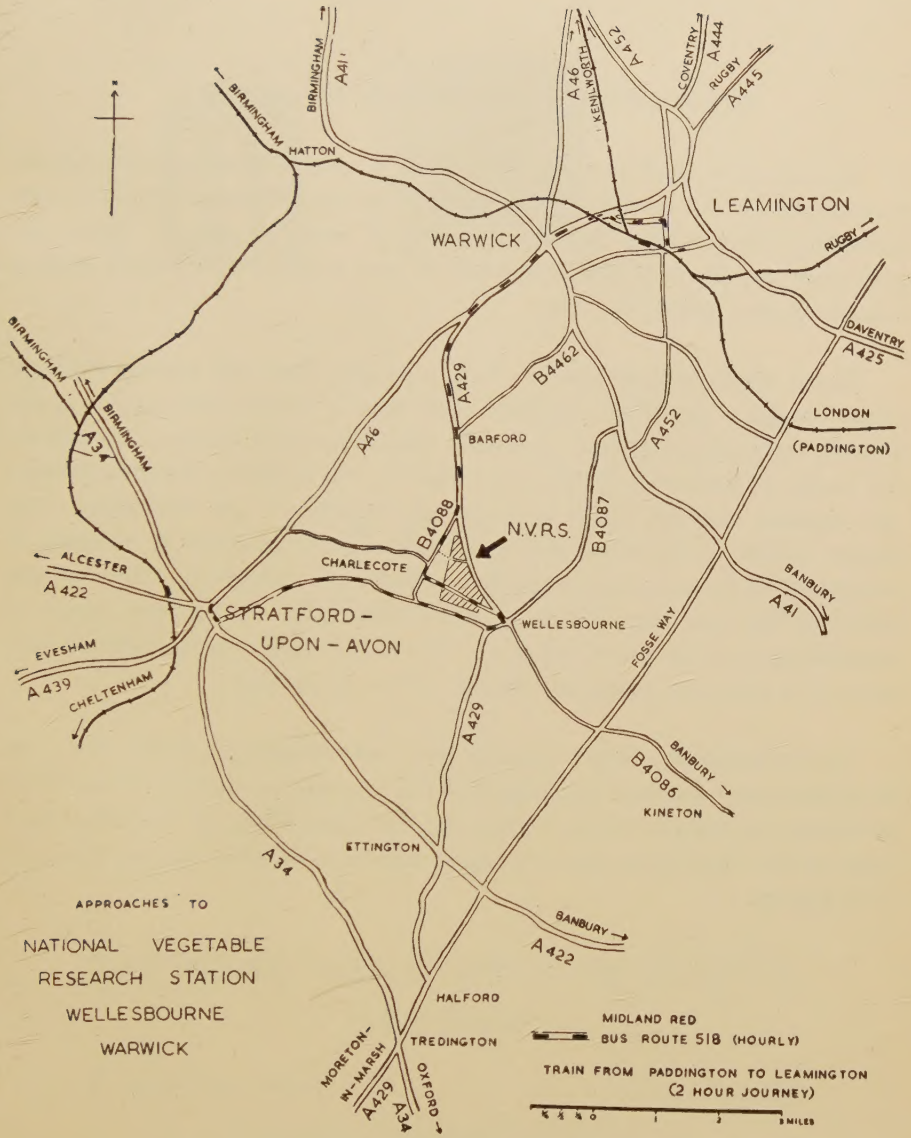
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THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home or abroad. Papers for publication and all communications should be sent to the Editors at East Malling Research Station, Maidstone, Kent.

Recent papers describe work on fruit, vegetables, hops and flowers, including cultural studies ; the effects of mineral deficiencies in various crops such as apple, broccoli, cacao, potato, tomato, strawberry and bulbs ; fruit storage ; the biology and control of pests of fruit and their predators ; the control of fungous diseases, virus diseases, genetical studies of fruits and vegetables ; soil sterilisation. The current Volume 32 will include papers on the environmental effects on flowering of tomato, and of sowing and planting date on blindness in cauliflower. There are also reports on the water requirements of lettuce under glass, and on weed control in vegetable crops by the use of monuron. Two further papers on molybdenum deficiency, as it affects the tomato and lettuce, will also be included.

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